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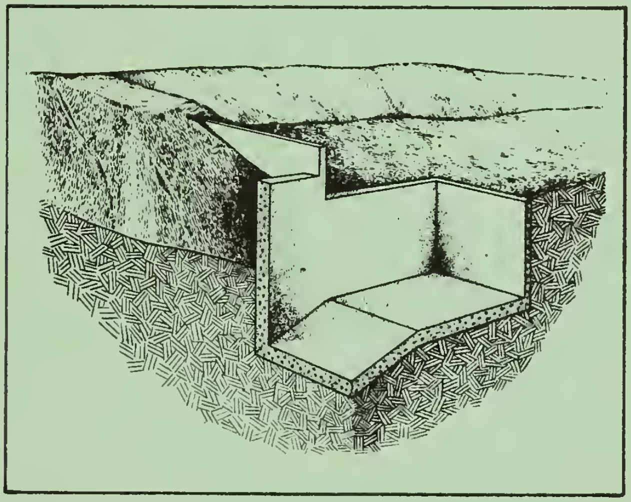

THE HYDRAULIC DESIGN OF RECTANGULAR SPILLWAYS

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FOREWORD

This report contains information for the hydraulic design of rectangular spillways, a structure which has been used extensively by the Soil Conservation Service in its erosion-control program.

The laboratory investigations were conducted by the Soil Conservation Service at the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota in cooperation with the Minnesota Agricultural Experiment Station.

The report contains a description of the structure with its application to field conditions, a brief description of the laboratory tests and analysis of data, a brief description of the method used in preparing rating tables for designing the spillway, and a description of the effect of various features of the spillway design on the carrying capacity including a correction to be applied for spillways subject to submerged conditions.

The writer wishes to acknowledge the assistance of Mr. Fred W. Blaisdell, who gave considerable time to the study of the hydraulic characteristics of the spillway during the preliminary laboratory investigations. Mr. Charles A. Donnelly made the major portion of the laboratory tests used in the calibrations of the spillway and also prepared many of the graphs used in the report. The writer is also indebted to Miss E. Clare Gosslin for her assistance in computing and checking the rating tables.

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FIGURES (Cont'd)

EXPLANATION OF SYMBOLS

B	Length of spillway crest from the upstream face of the bulkhead to the upstream weir crest
C	Coefficient in the formula $Q = CLH^{1.50}$
D	Vertical drop from spillway crest to floor of spillway
d	Depth of water above the spillway crest as measured in laboratory tests
D_c	Depth of approach channel below spillway crest at point of measuring water depth
g	Acceleration of gravity (32.2 ft./sec.^{2})
H	Total head on spillway. Water depth used in designing height of bulkhead above spillway crest
h_v	Velocity head in approach channel at head measuring section
L	Total inside length of spillway crest (2B + W)
Q	Discharge in cubic feet per second
T	Thickness of spillway crest
W	Width of spillway at upstream end and at bulkhead
W_c	Width of channel approaching spillway
X	Horizontal distance from toe of dike to inside of spillway crest at the bulkhead

THE HYDRAULIC DESIGN OF RECTANGULAR SPILLWAYS

By Albert N. Huff, hydraulic engineer, Division of Drainage and Water Control Research, Soil Conservation Service

PROBLEM

The rectangular spillway is a structure which has been used extensively for erosion control work in protecting the heads of gullies, especially where large quantities of water are involved and relatively small heads are available. The spillway itself is rectangular in plan and the outlet portion may be constructed in several ways, depending upon the field conditions. Only the results of a limited number of experiments on "head spillways" made at the University of Wisconsin1/ in 1933 have been available for designing the rectangular spillway when used as a drop box or as a U-type entrance for concrete flumes. It was, therefore, considered desirable as a part of the hydraulic research program to investigate this structure and to determine its capacity for a wider range in dimensions.

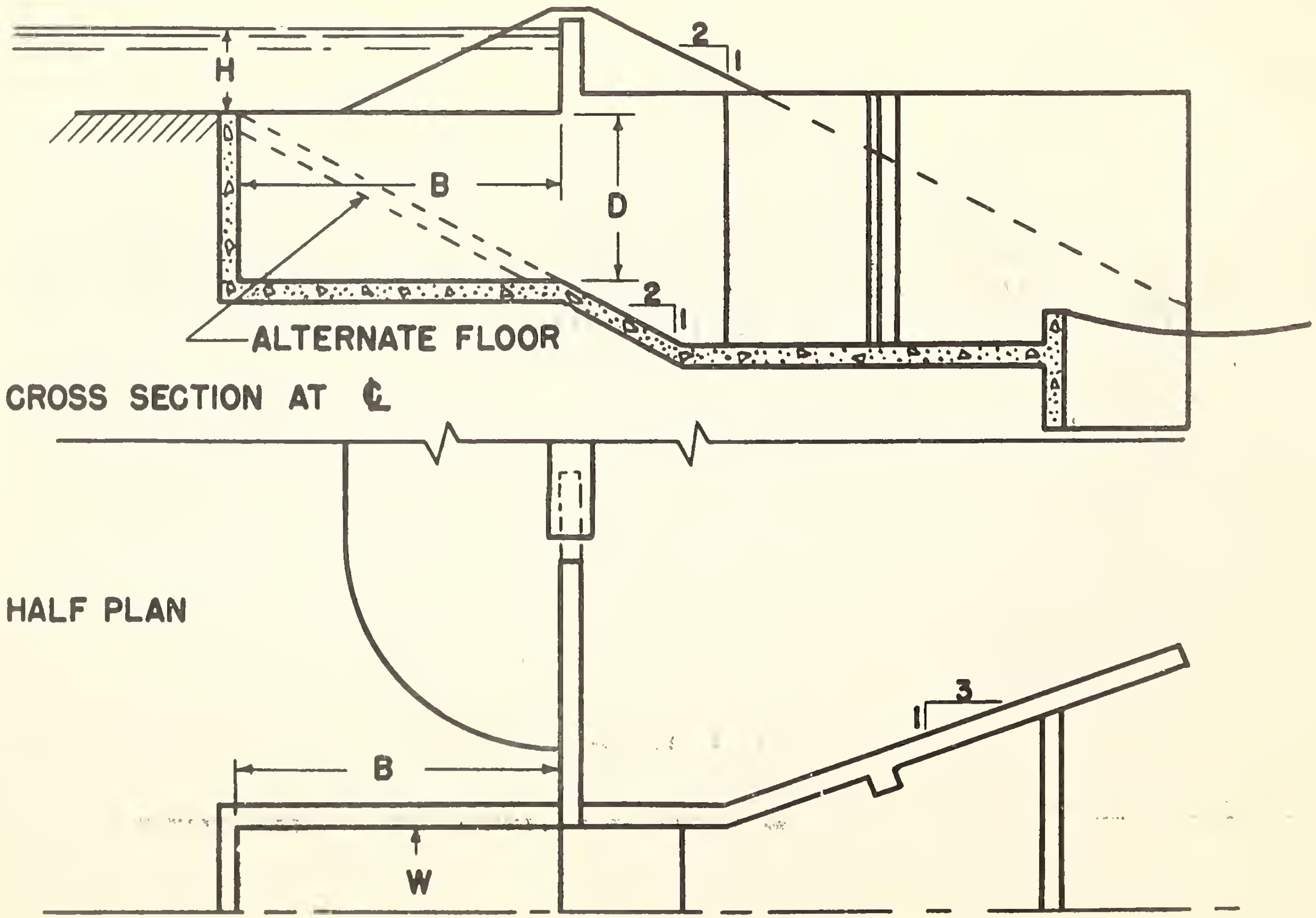
DESCRIPTION OF STRUCTURE

The rectangular spillway may be described as a structure consisting of three weirs at right angles to each other, forming three sides of a rectangular box. The fourth side of the box is open below the weir-crest elevation and there are bulkheads above the crest elevation on each side of the channel. The discharge over the three weirs drops into the box and passes through the outlet in the open side. The rectangular spillway was first used by the Soil Conservation Service in the design of "head spillways" or "drop boxes." It has been used also as an entrance for concrete flumes and has usually been designated a "U-type" entrance. Professor Kessler,2/ in reporting his laboratory tests of the "head spillway" described it as "a concrete channel with a closed upstream end." The sketches in **figures 1, 2, and 3, pages 2, 3, and 4,** show the rectangular spillway with several modifications of the outlet.

FIELD APPLICATION OF STRUCTURE

When the rectangular spillway is used as an entrance for a flume, and in many cases as a head spillway or drop box, there is no bulkhead over the outlet end of the box. (See figs. 1 and 2.) However, in some cases roadways are constructed over the outlet of the head spillway and the outlet is covered at the elevation of the spillway crest. (See fig. 3.) A similar construction would also be used when the rectangular spillway is used as an inlet for a road culvert. These are the two general types of outlets which influence the capacity of the rectangular spillway. In order to determine the capacities of the spillway with the two types of outlets, a separate series of calibrations was made for each. The floor for the open-top outlets was dropped below the floor of the spillway, and the two floors were joined by a 2:1 slope (fig. 1) because it was found in developing a design of the outlet for drop boxes that it would be desirable to place the floor of the outlet below the grade of the channel in most cases. The results would also be more applicable for the design of flume entrances (fig. 2). For tests of the spillway with a covered outlet, the floor of the outlet was horizontal. Actually, the discharge capacity of the spillway is not influenced appreciably by changes in the floor of the outlet. When the horizontal floor is used, the capacity at the higher heads is reduced only slightly below the capacity of the spillway when the outlet floor is dropped.

1/KESSLER, L. H. Experimental Investigation of the Hydraulics of Drop Inlets and Spillways for Erosion Control Structures. Univ. Wis. Engin. Expt. Sta. Bul. No. 80. 1934.
2/ibid p. 57.



RECTANGULAR SPILLWAY
WITH OPEN TOP

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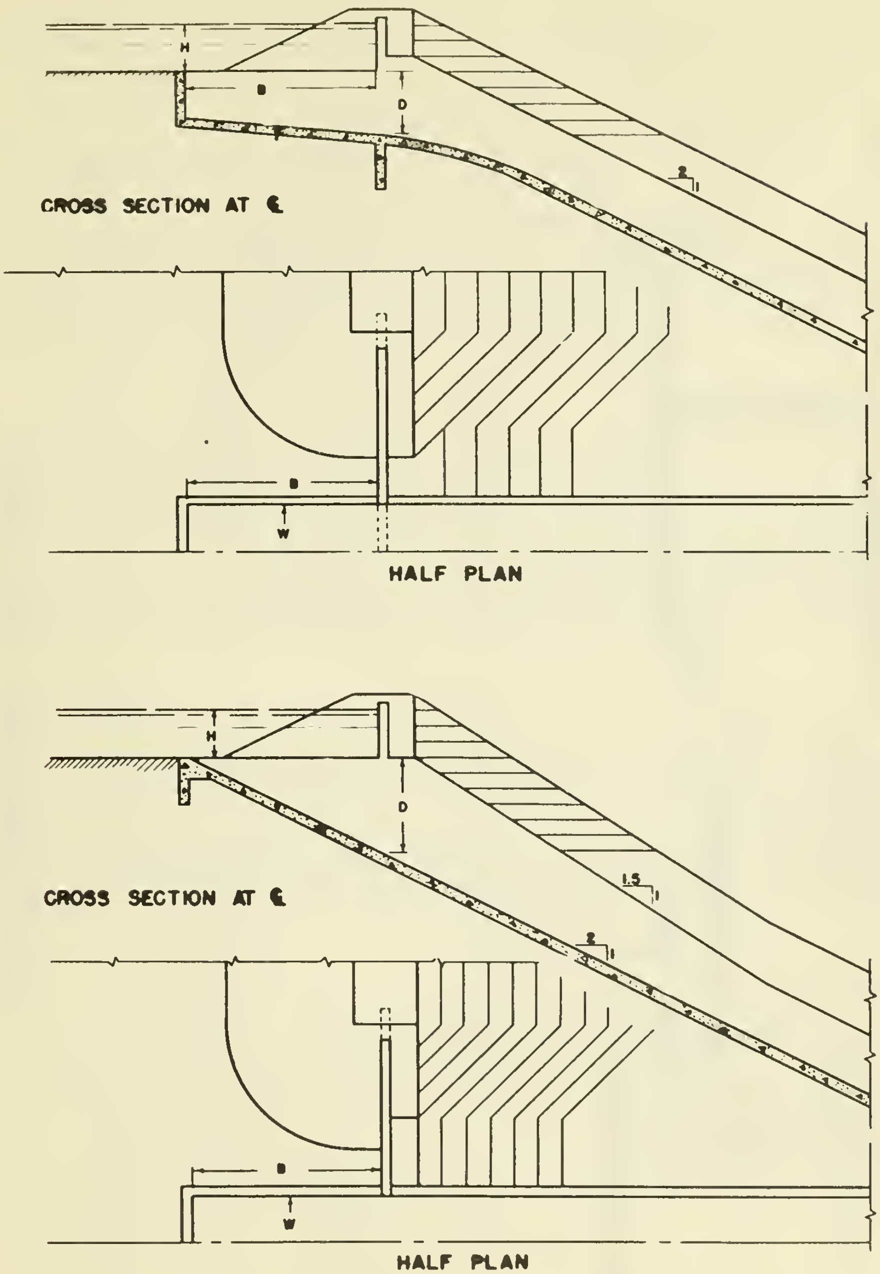
FIGURE 1



RECTANGULAR SPILLWAY FLUME ENTRANCES

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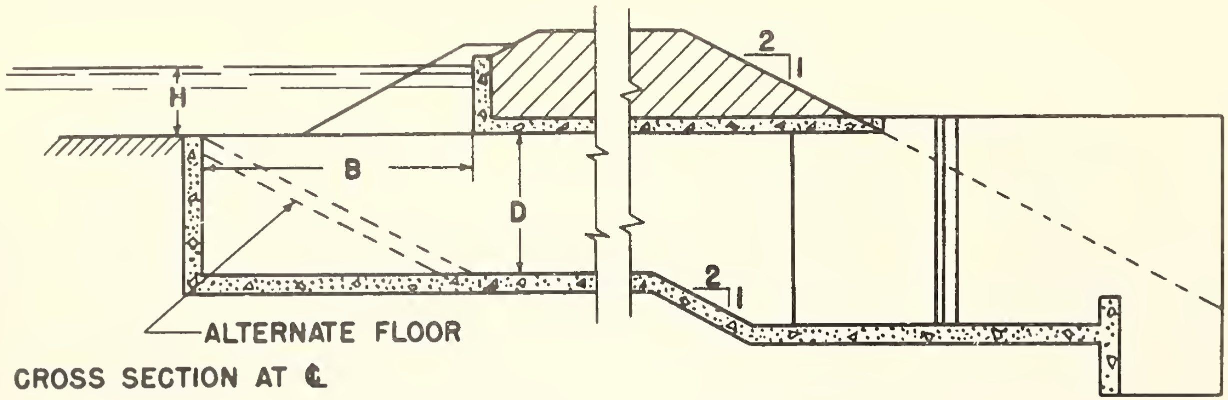
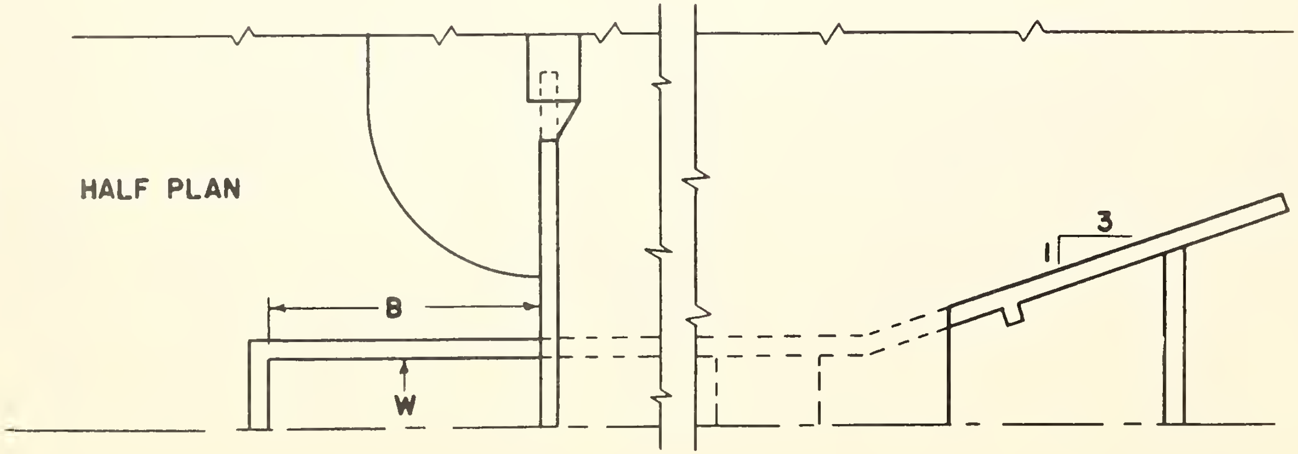
FIGURE 2



CROSS SECTION AT ℄



HALF PLAN

RECTANGULAR SPILLWAY
WITH CLOSED TOP

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FIGURE 3

HYDRAULIC LABORATORY TESTS

The rectangular spillway was first studied at the St. Anthony Falls Hydraulic Laboratory as an entrance for flumes. Some of the tests were made with a model having an inside width of 2 feet and a maximum length of 4 feet. The approach channel was only 8 feet wide and consequently the velocities of the water in the channel were rather high, especially for the models having the longest spillways. At the time these tests were made the number of measurements of the upstream water depth obtained were insufficient to accurately determine the proper head on the spillway for designing the structure. There was also some doubt as to the accuracy of the discharge measurements, especially for the lower flows, since a 9-foot weir was used as a measuring device. A series of tests was also made on a rectangular spillway having a width of 12 inches and constructed at the entrance to the flume. All of these tests for flume entrances were reported in March 1941 in a report entitled "Design of U-Type Entrance Flumes." This report was never released for general distribution, and it is now superseded by the information contained in this report.

It was decided to construct small-scale models in a 3-foot-wide test channel for making a more extensive study of the spillway. In order to study the flow through the spillway and also make it possible to develop an outlet for it, a half-section model of the spillway was constructed with the centerline section placed against a plate glass in one side of the test channel. This made it possible to observe the flow through the spillway. Experience with other models has proved that data obtained with a half-width model of a structure which is symmetrical about the centerline are representative of conditions existing in a full-width model and that the laboratory measurements may be used with the same degree of accuracy.

Description of Models

All of the models used for making the calibrations of the rectangular spillway were constructed of concrete with a steel plate for the weir crest. Pictures 898, 894, 929, and 927 in figure 4, page 6, show some of the models as constructed for the calibrations. Other pictures in figure 4 are similar to those used for the calibrations, but are of temporary wood construction as used for developing a design for an outlet structure. Considerable care was taken to construct the models accurately with the steel spillway crest set absolutely level. Most of the calibrations were based on tests of a model having a half-width of 4 inches. However, in order to calibrate the spillways with lengths (B) in the direction of flow equal to twice the width (W) with the maximum amount of water which could be measured with the type HS flume used for measuring the discharge, it was necessary to use a model having a half-section width of 3 inches. Tests of the 3-inch half-model checked very closely with similar tests, using a 4-inch half-model.

In order to obtain more accurate measurements of discharge for the spillway with a relatively short length (B), a 6-inch half-width model was used for some of the tests with other dimensions increased accordingly.

Tests Used for Calibrations

In order that adequate data would be obtained for designing spillways covering a wide range of dimensions, three ratios of width of spillway (W) to depth of spillway (D) were chosen so that W = D, W = 2D, and W = 4D. For each of these depths three lengths (B) of spillway were chosen so that B = 0.5W, B = W, and B = 2W. Additional tests were made later for the open-top spillway where the length (B) was equal to 0.25W, 0.125W,

HALF-SECTION MODELS OF RECTANGULAR SPILLWAY

(1009)

B=0.5W W=4D H/L=.112

(998)

B=0.5W W=2D H/L=.112

(1002)

B=0.5W W=4D H/L=.188

(992)

B=0.5W W=2D H/L=.188

(1007)

B=W W=4D H/L=.075

(898)

B=2W W=2D H/L=.048

(1004)

B=W W=2D H/L=.120

(894)

B=2W W=2D H/L=.057

(990)

B=W W=D H/L=.120

(929)

B=2W W=D H/L=.056

(984)

B=W W=D H/L=.180

(927)

B=2W W=D H/L=.087

FIGURE 4

and zero. Table 1, page 8, gives a list of the tests used for calibrating the rectangular spillway with open-top outlet and closed-top outlet.

Measurement of Water Depth

The depth of flow in the upstream pool above the spillway was measured at several locations in the first tests in order to determine the highest level for design purposes. After making several tests it was found that the height of water at the bulkhead or on the dike at the side of the spillway was very nearly equal to the total head at a distance upstream from the bulkhead of about 2B. Consequently, all of the head measurements used in preparing the calibration data are based on depth measurements at least 28 inches upstream from the bulkhead on the 4-inch half-section model. The total head at this point is the sum of the observed depth and the velocity head. A piezometer opening in the floor of the approach channel was used for measuring the head although check measurements were also made with a surface point gage.

Measurement of Discharge

The discharge through the model was measured by means of a 1-foot type HS measuring flume which had previously been calibrated by means of weighing tanks. The accuracy of the discharge measurements was within 1 percent. The discharge, as measured through the half-section model was doubled in order to give the discharge which would have been measured through the full-width model. Flow of water into the test channel was directly from the river and was regulated by a 4-inch valve. A relatively constant stage in the river during the tests made fluctuations in flow negligible.

ANALYSIS OF DATA

The first step in analyzing the data obtained in calibration tests of the rectangular spillway was to compute for each test run, the total head based on the depth of flow measured above the crest elevation. This was accomplished by determining the mean velocity (v) at the head measuring section in the approach channel and the corresponding velocity head (h_v). This was added to the observed flow depth (d) to get the total head (H). As stated previously, it was found that the height of water on the bulkhead was very nearly equal to the total energy head existing in the approach channel upstream from the spillway.

Head Discharge Curves

In order to study the hydraulic characteristics of the rectangular spillway, the various total heads (H) for each test run were plotted against the corresponding discharge (Q) for a full-width model. (The discharge, as measured in the half-section model tests was doubled to get the rate of flow through a full-width model.) The logarithmic plots in figure 5, page 9, indicate the type of curves which were obtained. The various tests having the same ratio of length to width but different depths (D) have been grouped together. It will be noticed that a spillway having a given length and width functions as a weir until a head is reached where the spillway crest begins to be flooded out from the effect of the outlet depth at the bulkhead. This is the point on the curve where the head-discharge curve breaks away on a much steeper slope. As would be expected, the head at which the spillway begins to flood out is much higher for the deep outlet than for the shallow outlet.

TABLE 1.--*Dimensions of models used in calibrating rectangular spillway*

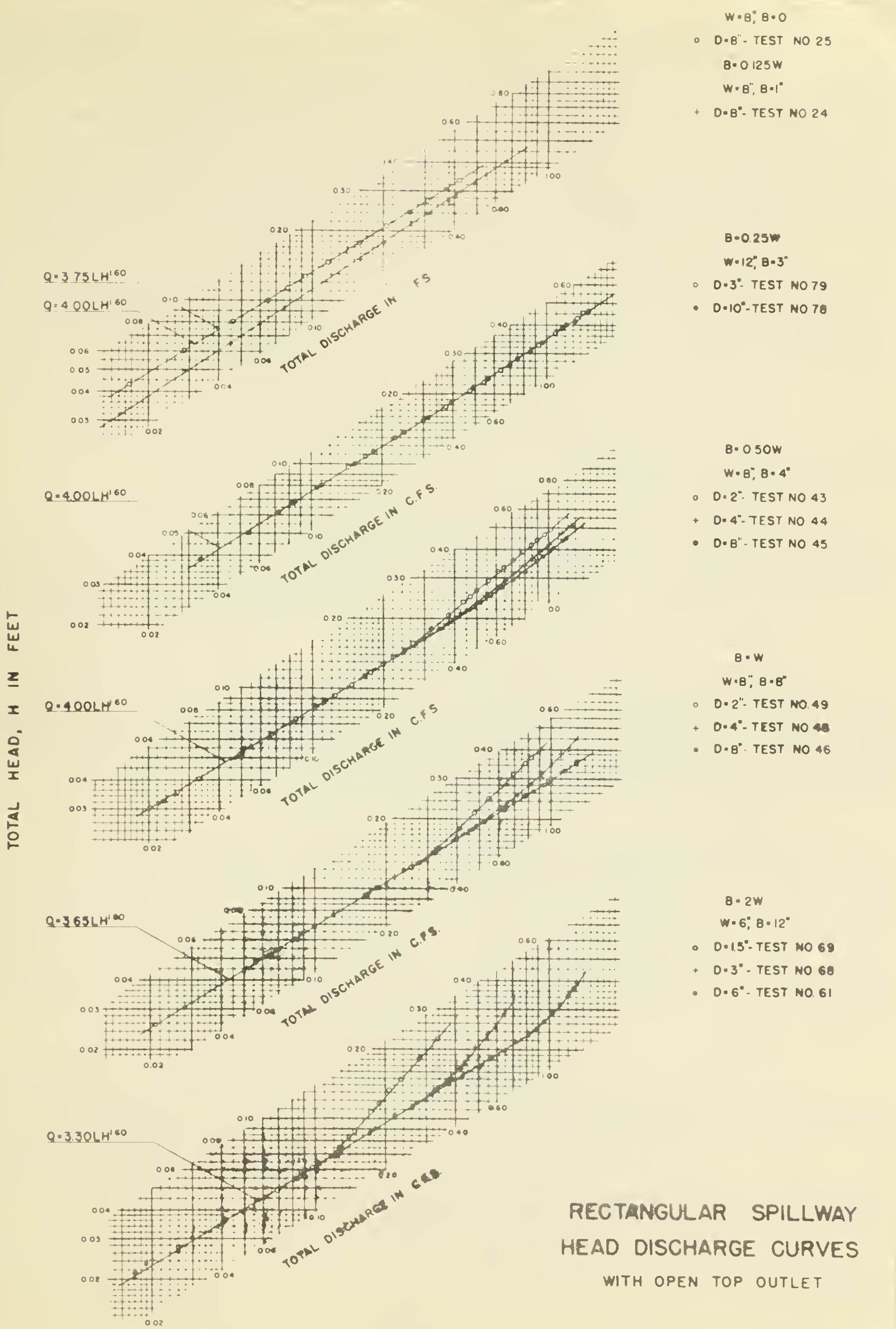
OPEN-TOP OUTLET

Test No.	W in.	B in.	D in.	L[1] ft.	W_c ft.	B/W	W/D	W_c/L
25	8	0	8	0.67	3.0	0	1	4.50
24	8	1	8	.83	3.0	0.125	1	3.60
78	12	3	10	1.5	2.25	.25	1.2	1.50
79	12	3	3	1.5	2.25	.25	4	1.50
43	8	4	2	1.33	3.0	.50	4	2.25
44	8	4	4	1.33	3.0	.50	2	2.25
45	8	4	8	1.33	3.0	.50	1	2.25
49	8	8	2	2.0	3.0	1.0	4	1.50
48	8	8	4	2.0	3.0	1.0	2	1.50
46	8	8	8	2.0	3.0	1.0	1	1.50
69	6	12	1.5	2.5	6.0	2.0	4	2.40
68	6	12	3	2.5	6.0	2.0	2	2.40
61	6	12	6	2.5	6.0	2.0	1	2.40

CLOSED-TOP OUTLET

Test No.	W in.	B in.	D in.	L[1] ft.	W_c ft.	B/W	W/D	W_c/L
5	8	4	8	1.33	3.0	.50	1	2.25
11	8	4	4	1.33	3.0	.50	2	2.25
17	8	4	2	1.33	3.0	.50	4	2.25
3	8	8	8	2.0	3.0	1.0	1	1.50
9	8	8	4	2.0	3.0	1.0	2	1.50
15	8	8	2	2.0	3.0	1.0	4	1.50
82	6	12	1.5	2.5	3.0	2.0	4	1.20
83	6	12	3	2.5	3.0	2.0	2	1.20
84	6	12	6	2.5	3.0	2.0	1	1.20

[1] $L = 2B + W$. Since H was measured in feet, L is shown in feet for computing H/L values more easily.



RECTANGULAR SPILLWAY
HEAD DISCHARGE CURVES
WITH OPEN TOP OUTLET

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FIGURE 5

The head-discharge curves have been presented to illustrate the hydraulic characteristics of the rectangular spillway with open-top outlet. The curves for the spillway with covered outlet are exactly the same except that the upper portion of the curves rises more steeply when the outlet section begins to affect the flow through the structure. These data, as computed from the laboratory tests, have been used in plotting the curves shown in figure 5, page 9, and since three different sizes of models were used, no direct comparison can be made in the discharge capacity for the same head on the spillway for all of the tests. However, since the same width and length of model were used for different outlet depths, the comparative effect on the discharge capacity of the spillway depth is apparent.

The coefficient C in the weir flow formula $Q = CLH^{1.60}$ for each group of tests having different ratios of spillway length to width indicates, in general, the effect of the length-width ratio on the discharge capacity. (The logarithmic plots of all the tests of rectangular spillways had an exponent of 1.60 for the total head (H)). It will be noted in figure 5 that the coefficient for the spillway having $B = 2W$ is 3.30 while lengths from $0.125W$ to $0.5W$ have a coefficient of 4.00. It is interesting to note that when the total spillway crest has a total length (L) equal to W ($B = 0$) the coefficient drops back to 3.75. As will be shown later, the coefficient in the equations will vary somewhat with different approach channel widths.

In attempting to find some simple means of applying the laboratory data to the design of rectangular spillways, considerable study was given the problem. As already shown by the head-discharge curves, the coefficient in the equation $Q = CLH^{1.60}$ varies with different ratios of length to width. It would be rather simple to prepare a table of coefficients to be used in this formula for designing spillways having different width-to-length ratios. However, this formula is not applicable to prototype structures having much larger dimensions than the laboratory model used in making the calibrations because of the value of the exponent. In order to apply the coefficient, as determined by the laboratory model, to a structure having similar dimensions, the exponent of H must have a value of 1.50. Furthermore, even though such a formula, based on the laboratory tests, should be used in the design of a prototype structure, it would be applicable only for heads on the structure below which the spillway begins to flood out.

A great many of the rectangular spillways constructed in the past have been designed with maximum heads below the point at which the spillway begins to flood out. This practice was the result of design methods recommended on the basis of early laboratory studies made on "head spillways" at the University of Wisconsin.[3] When those studies were made, it was assumed that the surface of the flow passing through the outlet section at the bulkhead would have to be kept at the elevation of the spillway crest. However, even though the discharge increases at a slower rate with increase in head above the point at which the spillway floods out, it will be found much more economical, in many cases, to use design heads above the point of flooding, especially with open-top outlets.

It is apparent from the head-discharge curves that it would be an impossibility to write an accurate equation for discharge based on water depth over the spillway which would be applicable for the higher heads where the depth of the outlet controls the flow. Several attempts were made to find some criterion which would definitely determine the water depth at which the various types of spillways would flood out so that it might be possible to use a different formula for designing the spillway for higher heads. However, no successful solution to the problem was found.

3/Ibid p. 63.

Coefficient Curves

It was therefore decided to prepare coefficient curves for the various tests using the weir formula $Q = CLH^{1.5}$ with the idea of using this formula for design purposes throughout the full range of head. By using the water depth (H) with an exponent of 1.5 and a variable coefficient (C) instead of a constant coefficient, the equation could be used in designing any size of prototype structure if the value of C for similar geometric dimensions was used. In order that the proper value of C could be selected, it was plotted against the ratio of water depth to spillway crest length (H/L). The value of H/L is a dimensionless number which gives the same value of the coefficient for similar heads on any size of structure. By plotting the coefficient curves on logarithmic paper a straight line was obtained for that portion of the curves where the flow over the spillway is not influenced by the depth of the outlet. (See figs. 6, 7, and 8, pp. 12, 13, and 14.) When the depth of the outlet begins to control the flow, there is a decrease in the value of the coefficient for the spillway which is more pronounced for the spillway with the covered outlet.

The coefficient curve shown in figure 7 for the open-top outlet where B - 0.25W shows that the depth of the outlet has very little effect on the spillway capacity where the value of B is small relative to W. The two tests that were made with values of W equal to 1.2D and 4D plot very nearly the same curve, and consequently it may be assumed that this curve is applicable for designing any spillway of this shape for values of W which do not exceed 4D. Coefficient curves for values of B - 0.125W and zero are shown so that they might be used in designing such spillways. However, they were not used in preparing the rating tables.

RATING TABLES

The data given in the coefficient curves make it possible to design many types of spillways with various combinations of length and width, and having various depths. However, due to the fact that, for practical reasons, only a limited number of spillway models were calibrated, the number of shapes of spillways with different depths is rather limited. For instance, using the coefficient curves shown in figure 6 for the open-top spillway, there are only three ratios of length to width of spillway, viz., lengths of 0.5, 1.0, and 2.0 times the width. No doubt one of these ratios of length to width might be selected as suitable for a given field installation. However, since only three depths of the spillway were calibrated for each of the length-to-width ratios, there are actually only three widths of spillway for each depth. In order that the most economical and adaptable spillway might be used for each individual field installation, it was considered desirable to have a wider selection of shapes than were used in the laboratory calibrations. As an example, let it be assumed that there is a condition in the field which will require a spillway having a depth of 6 feet. It would be necessary to select a structure exactly similar to the laboratory models, and therefore, the width would have to be 6, 12, or 24 feet. However, it might be desirable for practical and economic reasons to select a width of 8, 10, 14, 16, or 20 feet. Likewise, for each width, there would be only three lengths to choose from. For the 6-foot width lengths of 3, 6, and 12 feet could be used; for the 12-foot width the corresponding lengths would be 6, 12, and 24 feet. However, it might be more economical to select an intermediate length.

In order that a wider selection of spillway sizes and shapes might be available for field use, it was decided to prepare a series of rating tables which would give the discharge capacity for many different spillway shapes and sizes for each 0.5-foot of head. A description of the procedure used in preparing the rating tables is given in appendix C, page 63, of this report.

RECTANGULAR SPILLWAY

WITH OPEN TOP OUTLET

COEFFICIENT CURVES

$Q = CLH^{1.5}$

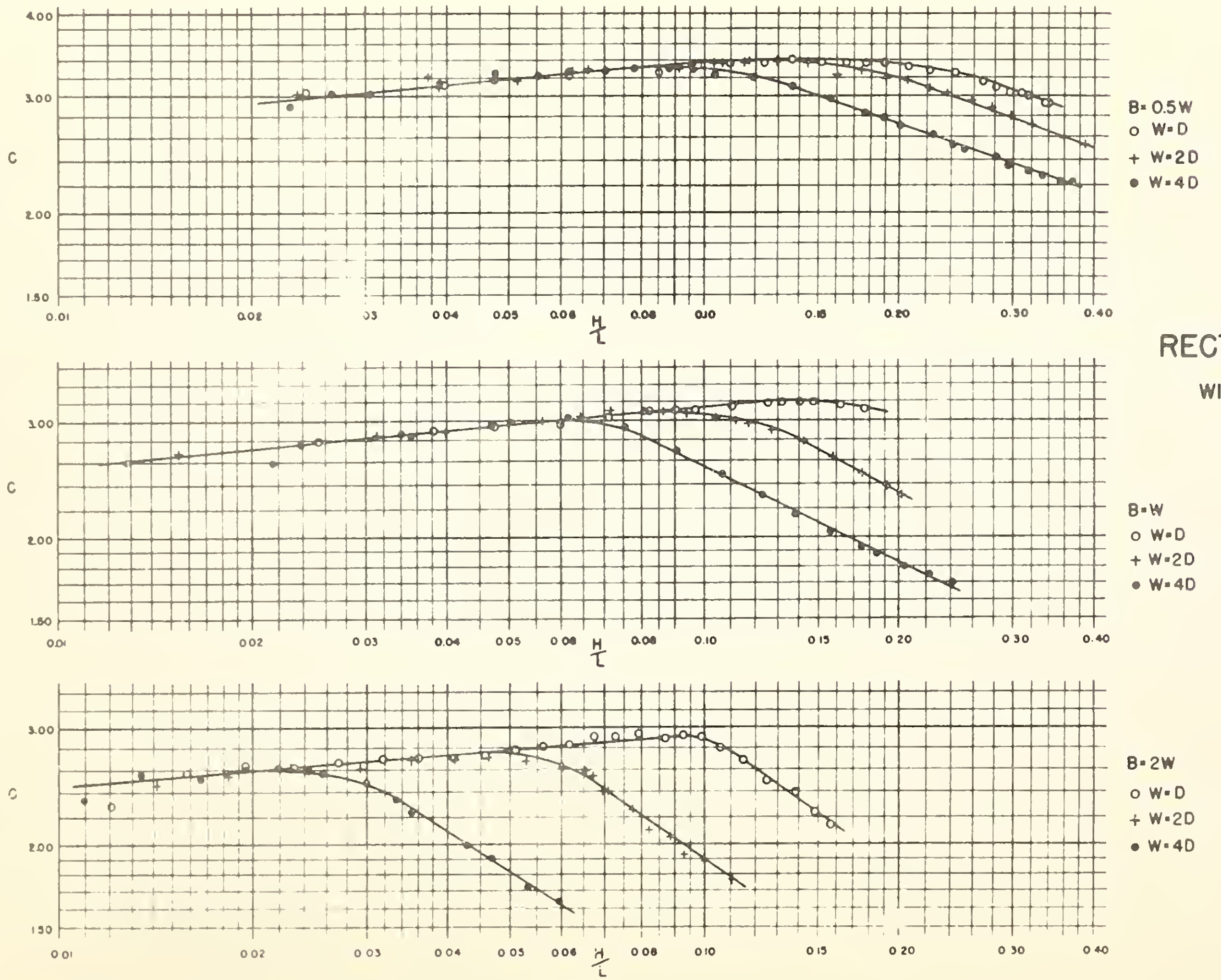

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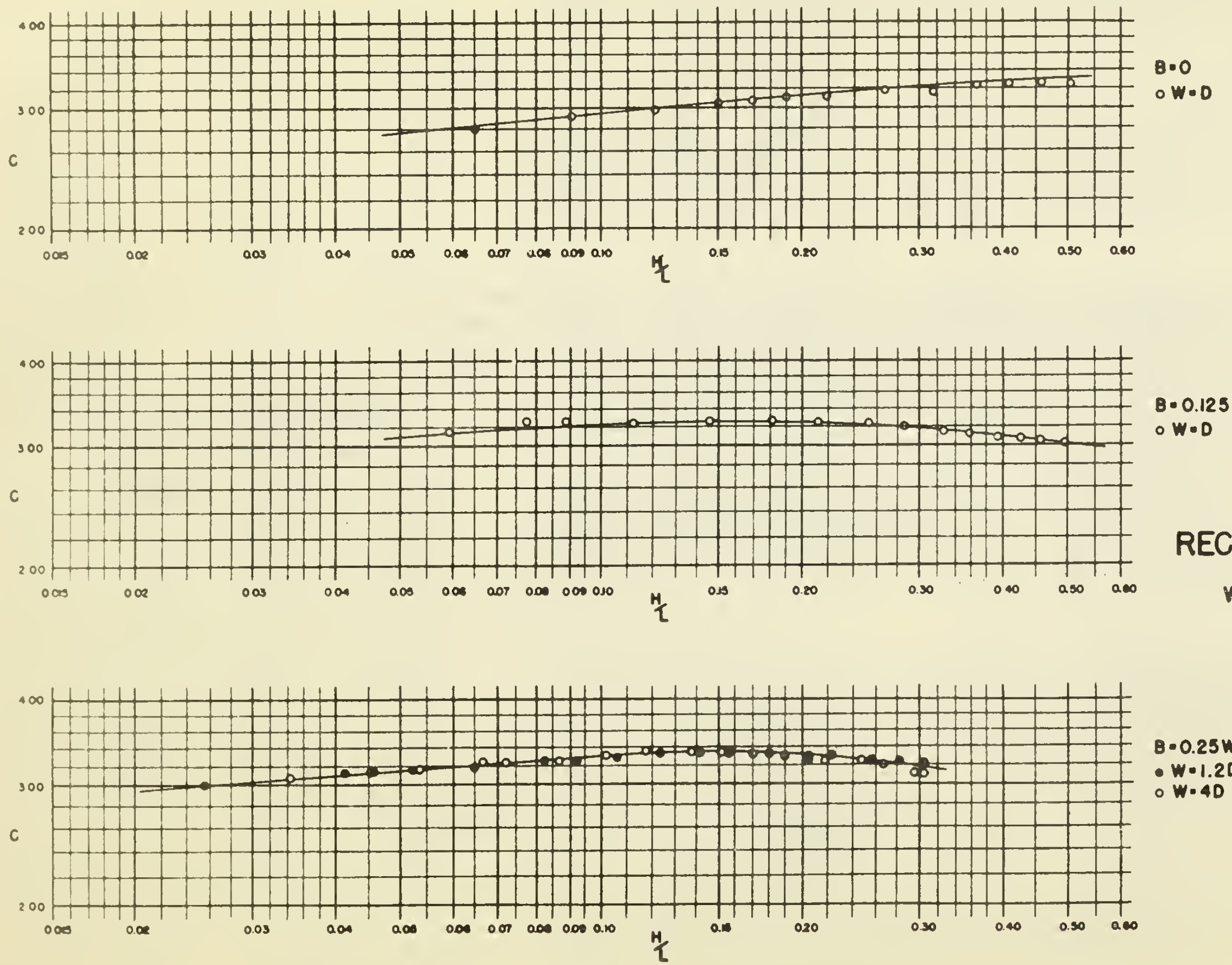
FIGURE 6



RECTANGULAR SPILLWAY
WITH OPEN TOP OUTLET
COEFFICIENT CURVES
$Q = CLH^{1.5}$

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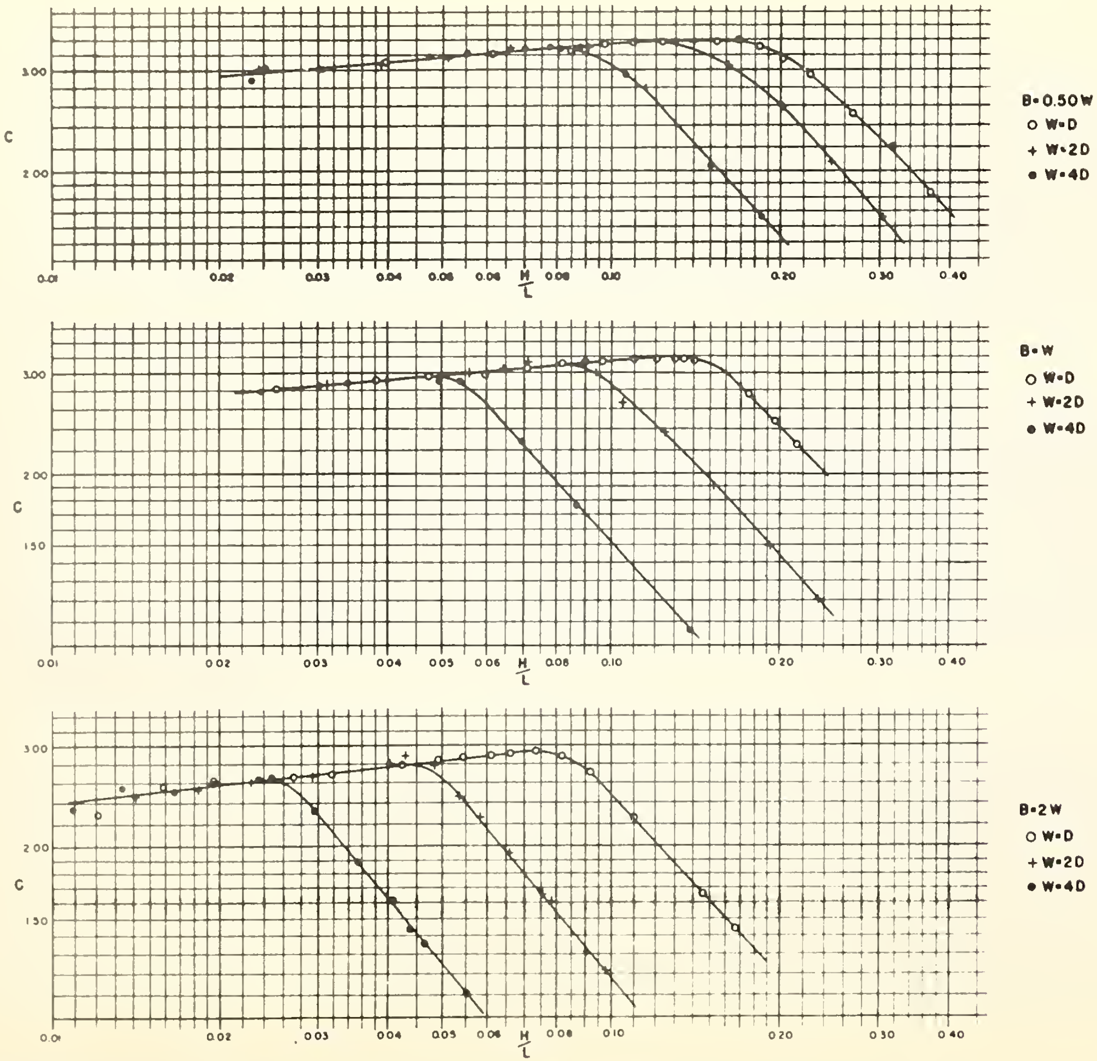
FIGURE 7



RECTANGULAR SPILLWAY

WITH CLOSED TOP OUTLET

COEFFICIENT CURVES

$Q = CLH^{1.5}$

FIGURE 8

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The rating tables were prepared so that all discharge values for a given depth D are together. This was done to simplify their use because, in designing a structure for the field, the depth of the spillway is usually determined by the field conditions; or, if it is to be varied by the design, it will be within narrow limits. The heading at the top of each table shows the depth for which it is applicable. Rating tables for the rectangular spillway with open-top outlet are given in appendix A, page 27, and tables for the spillway with closed top are given in appendix B, page 46 .

In the left column the width of the spillway is tabulated by 2-foot intervals up to 20 feet and by 4-foot intervals for wider spillways. Spillways with a width less than the depth, or greater than four times the depth, are not shown because they are beyond the range of the calibrations.

For each group of spillway widths there are various lengths, ranging from not less than 0.25W to not more than 2W, which is the range of the tests used in preparing the tables. The lengths are given by 2-foot intervals up to 20 feet and by 4-foot intervals beyond 20 feet.

In addition to offering a selection in the width and length of the spillway for various depths, the discharges for various water depths over the spillway crest are given in intervals of 0.5 foot up to a maximum of 5 feet for the open-top spillway and up to a maximum of 6 feet for the closed-top spillway.

It will probably be unnecessary to use dimensions of the rectangular spillway other than those given in the rating table. However, if it is found desirable to use intermediate dimensions, straight line interpolations between the values in the tables may be used. Discharge capacities for spillways having depths of 7 feet or 9 feet may be interpolated from corresponding W, B, and H values, from the tables for D = 6, 8, and 10 feet. As stated previously, coefficient curves for the open-top spillway were prepared for B values of 0.125W, and zero which may be used for designing spillways of that shape. See figure 7, page 13.

Example

The following example illustrates the procedure used in designing a rectangular spillway.

Assume that topographic conditions at the site require a spillway depth (D) of 7 feet and that the total head (H) cannot exceed 4 feet. The flow (Q) through the structure is 548 c.f.s. No roadway across the dike is necessary, and an open-top outlet may be used. The appropriate discharge tables are found in appendix A, page 27. The following dimensions (to the nearest 6 inches) may be obtained from the tables for Q = 548 c.f.s.:

D = 6 feet
H = 4 feet

W	B
6	10' -0''
8	7' -6''
10	5' -6''

D = 8 feet
H = 4 feet

W	B
8	6' -6''
10	5' -6''

By interpolation we get for $D = 7$ feet and $H = 4$ feet

W	B
8	7' -0''
10	5' -6''

The same problem will now be solved using the coefficient curves to illustrate that method of solving the problem if, for some reason, the tables cannot be used.

To begin with, it will be assumed that a spillway having a shape of $B = 0.5W$ and a depth of $W = 2D$ will be satisfactory. Since site conditions require that $D = 7$ feet, we get $W = 2D = 14$ feet, $B = 0.5W = 7$ feet, and $L = 2B + W = 28$ feet. Substituting in the formula $Q = CLH^{1.5}$ we get

$$548 = C \times 28 \times H^{1.5}$$

or

$$CH^{1.5} = 19.6$$

Since $H/L = 4 \underline{+}/28 = 0.14\underline{+}$, we enter the curve for $B = 0.5W$ and $W = 2D$ of figure 5, page 9, and find that $C = 3.4$. Solving for H,

$$H^{1.5} = \frac{19.6}{3.4} = 5.76$$

$$H = 3.21 \text{ feet.}$$

Assuming a new H/L value of $\frac{3.21}{28} = 0.11$, we find that $C = 3.4$.

Since this is the same as was assumed previously, no additional trials are necessary in this case. A rectangular spillway having the dimensions $B = 7$ feet, $W = 14$ feet, $D = 7$ feet, and $H = 3.21$ feet can therefore be used in place of the spillways listed above.

The dimensions of the rectangular spillway will depend on the topography and the relative cost of the structure investigated. It would also be advisable to compare costs for structures using lower values of H, especially for those locations in which a long dike is required.

HEIGHT OF BULKHEAD

The value of H in the rating tables for designing the rectangular spillway is the maximum depth of water above the crest elevation which will occur at the bulkhead or along the earth dike. In the majority of field installations the actual water depth at the bulkhead will probably be slightly less than that given in the rating tables. However, in order to provide some freeboard for wave action and surging for maximum flows, it would probably be advisable to construct the bulkhead 0.5 foot higher than the design depth H.

LOCATION OF DIKES

In making the laboratory tests, the toe of the dikes at the sides of the spillway were kept at a distance from the spillway crest equal to the head on the spillway. Although the capacity of the spillway is not greatly reduced, if the dikes are run closer to the crest the higher velocities around the dikes might not be desirable. It is, therefore, recommended that the distance (X) between the toe of the dikes and the inside of the spillway crest be kept at least equal to the design head on the spillway.

EFFECT OF SLOPING BOTTOM IN SPILLWAY

Several tests were made with the bottom of the spillway on a 2:1 slope as shown by the alternate floor on the spillway sketches in figures 1 and 3, pages 2 and 4, and one type of flume entrance in figure 2, page 3. There was no significant difference between the discharge capacity with the sloped bottom and that with the horizontal bottom. It may be assumed, therefore, that the only depth which must be considered in designing the spillway is the depth at the bulkhead. Any depth at the upstream end of the spillway which will best fit the topographic condition in the field may be used even though the floor may start at the crest elevation.

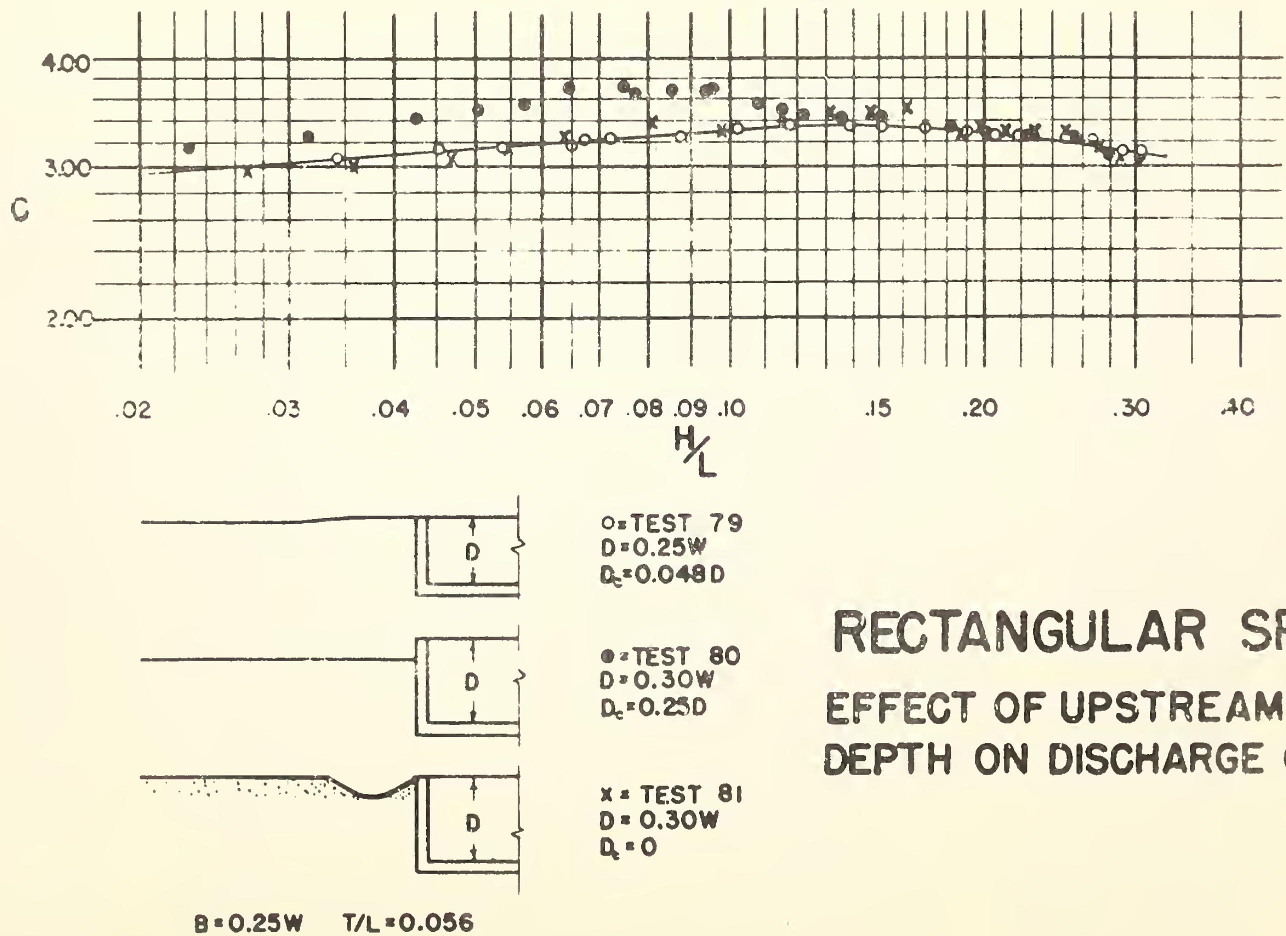
EFFECT OF APPROACH CHANNEL DEPTH

As stated previously, all calibrations of the rectangular spillway on which the rating tables were based were made with the approach channel flush with the crest elevation or just slightly below. This will be the condition which will undoubtedly prevail at most installations shortly after construction because the approach channel will silt in flush with the crest elevation. However, there may be some cases where the crest elevation will be considerably above the approach channel for some time after construction. In order to find out what effect this would have on the capacity of the spillway, test 80 was made with the spillway crest above the approach channel. The thickness of the crest (T) was made 1/2 inch and the top of the crest was 1 inch above the approach channel, making the depth $D = 0.3W$. Assuming the model represented a spillway crest having a 6-inch thickness, the height of the crest above the approach channel would be 1 foot. The coefficient in the formula $Q = CLH^{1.5}$ was computed as in the other tests and plotted on the same sheet as for test 79, which had an approach channel nearly flush with the spillway crest and was used in calibrating the spillway. (See table 1, p. 8.) As shown by the plot in figure 10, page 19, the coefficient for heads up to the point where the spillway floods out is quite a little higher when the crest is above the bottom of the approach channel. This indicates that spillways designed by means of the rating tables will have adequate capacity before the approach channel is silted flush with the spillway crest because they will carry more water for the same head. (See fig. 9, p. 18.)

In order to determine what would happen if loose sand were placed in the approach channel, test 81 was made with a 1-inch depth of sand below the crest elevation. The sand was scoured out near the crest as shown by the sketch in figure 10. A calibration of the spillway with the sand scoured out at the spillway crest gave almost identical results as the calibration with the fixed approach channel flush with the crest.

EFFECT OF APPROACH CHANNEL WIDTH

In order to calibrate the spillway with a length equal to twice the width, it was necessary to use a model having a half-width of 3 inches. This model was constructed and tested with the same channel width as was used for the models with a 4-inch half-width. In order to check the test results of the smaller model, they were compared with tests of a similar model which had a half-width of 4 inches (test 56). After making proper

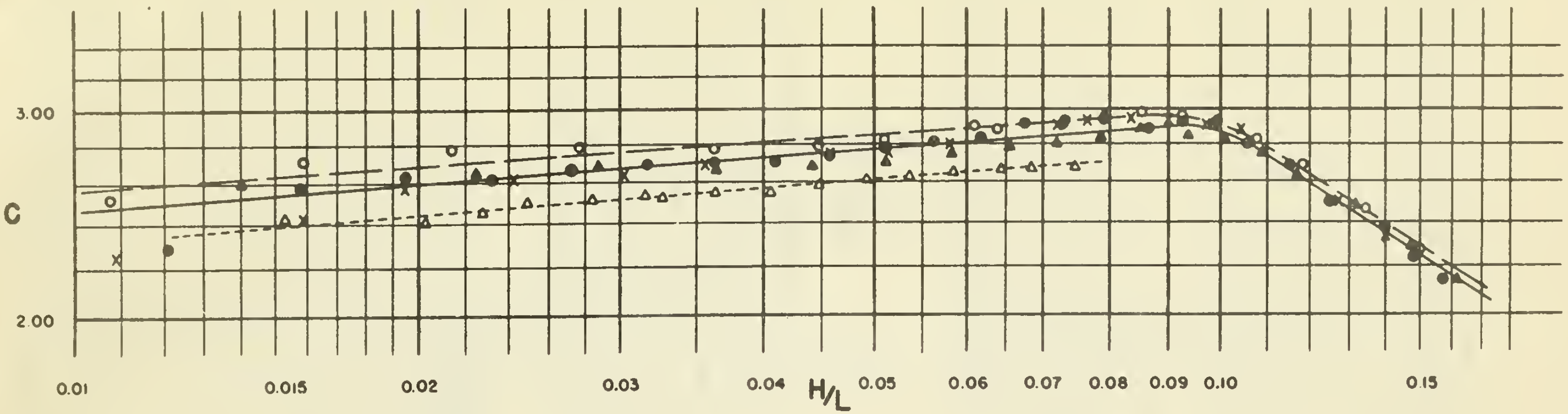


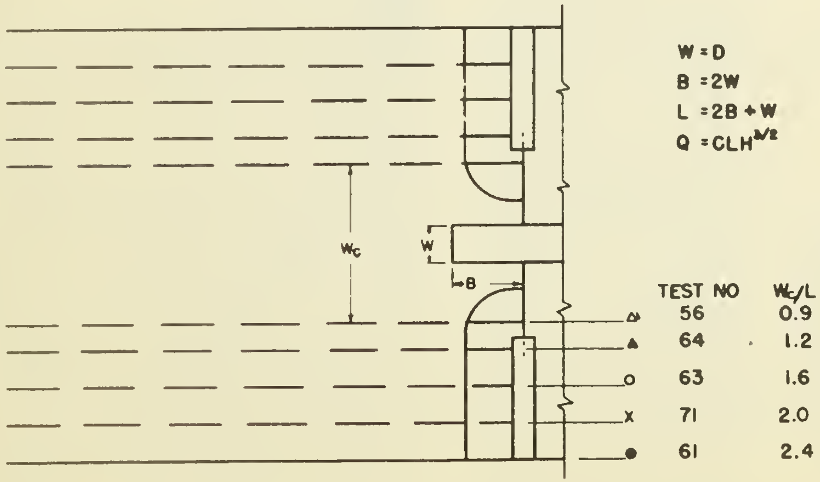
RECTANGULAR SPILLWAY

EFFECT OF UPSTREAM CHANNEL DEPTH ON DISCHARGE CAPACITY

S.C.S. PROJECT MN-R-3 SEPT 1943

FIGURE 9





RECTANGULAR SPILLWAY

EFFECT OF UPSTREAM CHANNEL WIDTH ON DISCHARGE CAPACITY

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FIGURE 10

adjustments in the data for the different size of model, it was found that the 3-inch half-width model gave a slightly higher discharge. The only dimension of the set-up for the two model tests which was not similar was the approach channel width, it being 18 inches wide (half-width) for both model set-ups. It was, therefore assumed that the relatively wider channel for the 3-inch model was influencing the discharge rate through the model.

In order to substantiate the fact that the width of the approach channel did effect the discharge capacity of the spillway, several tests were made with various ratios of channel width to weir-crest length. The data as plotted in figure 10, page 19, show that the highest coefficient in the weir formula is reached with a channel width (W_c), about 1.6 times the length of the spillway crest when B = 2W. Wide channels reduce the capacity slightly as well as channels which are too narrow. A complete series of calibrations for this spillway with various depths had been made with a channel width equal to 2.4 times the crest length and since the coefficients are only slightly less than the maximum for a slightly narrower channel, they were used in preparing the coefficient curves and finally the rating table. The rating tables will, therefore, give a design which will be conservative for channel widths between 1.2 and 2.4 times the crest length (L).

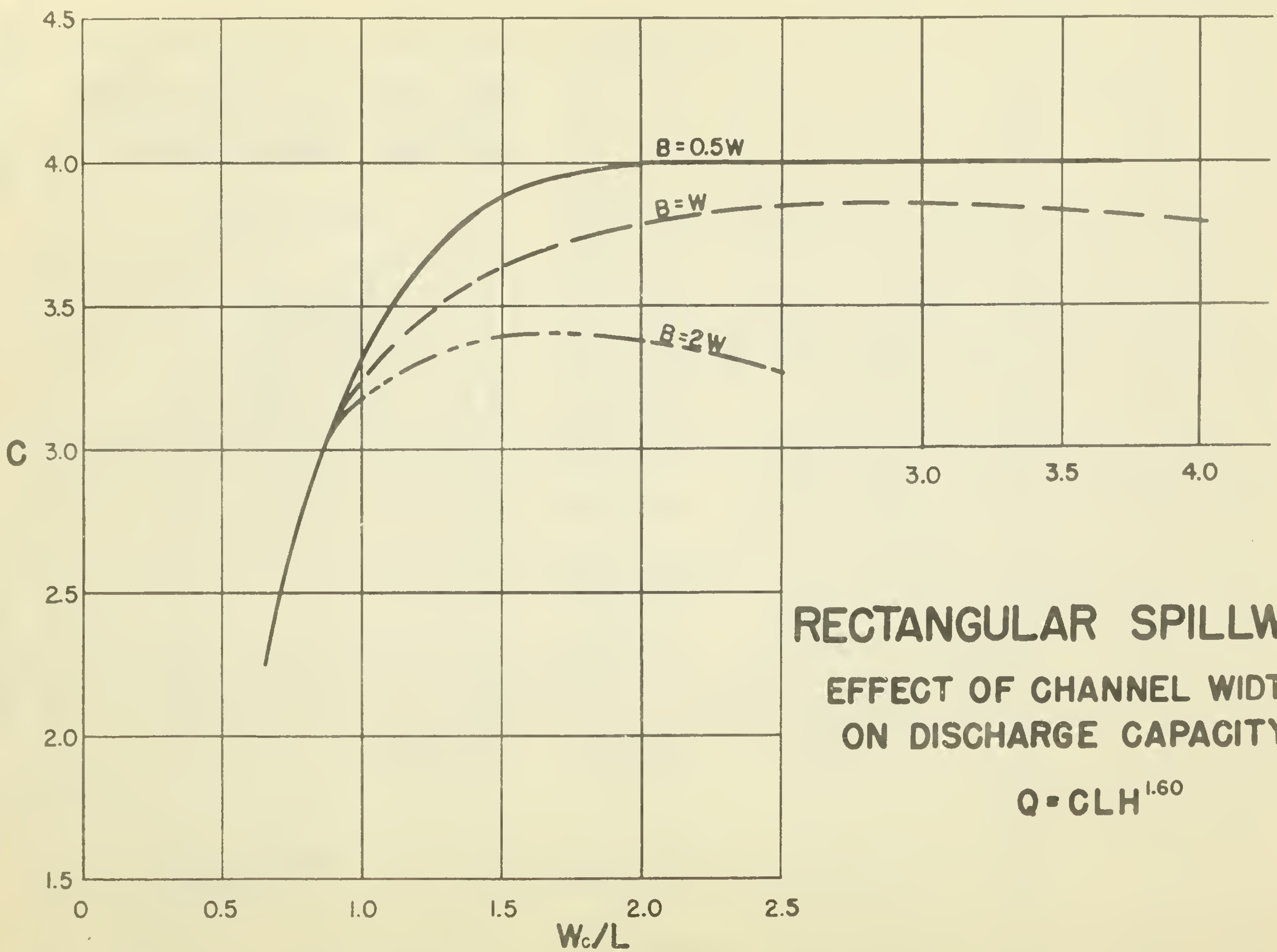
After making a study of the effect of channel width with a spillway having a length equal to twice the width, additional tests were made with various channel widths for other ratios of spillway dimensions. The curves plotted in figure 11, page 21, show the effect on the coefficient for the straight portion of the head-discharge curve. All of the equations for the spillways were of the form $Q = CLH^{1.60}$ as illustrated by the plot of head-discharge curves in figure 5, page 9. It will be noted that, in general, the maximum coefficients are obtained with a channel width 1.5 times the spillway crest length, although for spillways where B = W, the coefficient increases about 5 percent for channels 2.5 to 3 times the crest length. The groups of tests used in computing the coefficients and the rating tables had channel widths as follows:

B = 0.5W	$W_c/L = 2.25$
B = W	$W_c/L = 1.50$
B = 2W	$W_c/L = 2.4$

It will be noted that the tests used in calibrating the spillways had channel widths which gave conservative values of the coefficients. In some field installations the spillway may discharge slightly more than it is designed to carry,but in no case will the variation in channel width cut down the designed capacity as long as the channel has a minimum width equal to 1.5 times the spillway crest length. This value has therefore been selected as a minimum value for using the rating table.

EFFECT OF SUBMERGENCE

There may be some installations of the rectangular spillway which will be subject to high tailwater in the downstream channel causing the spillway crest to be submerged. In order to determine the effect of such submergence on the capacity of the spillway, several tests were made. All of the tests were made on a model of a spillway having a length equal to the width (square in plan) with W = D, W = 2D, and W = 4D. The procedure used in making the tests was to set a flow through the model with free-flow conditions in the downstream channel. The depth of water in the downstream channel was successively raised in small increments by means of a control gate. After each increase in tailwater depth, the depth of water in the upstream channel was measured after steady flow became established. This procedure was repeated for several different flows through the model.



RECTANGULAR SPILLWAY

EFFECT OF CHANNEL WIDTH ON DISCHARGE CAPACITY

$Q = CLH^{1.60}$

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FIGURE 11

Analysis of Data

The first step in studying the effect of submergence was to determine the increase in the head on the spillway for the corresponding submergence. The submergence as used in this study, and as used in making corrections in the design for submerged condition, may be defined as the ratio of the water depth in the downstream channel above the spillway crest to the actual depth over the crest in the upstream channel, expressed as a percentage. The increase in head for a given submergence is the difference between the actual depth with submergence and the freeflow head for the same discharge. Curves have been plotted in figures 12, 13, and 14, pages 23, 24, and 25, which show the percentage increase in the head on the spillway for various amounts of submergence. Figure 12 shows the effect of submergence with a deep spillway where W = D. It will be noted that there is a very marked increase in the head on the spillway with increase in submergence, there being a greater effect of submergence with the higher heads.

Figure 13 shows that there is less effect of submergence when the ratio of width to depth is larger (W = 2D). Figure 14 shows the results of tests made on the model where the width was four times the depth. There is a much smaller increase in head for a given submergence. This is due to the fact that the original freeflow head for the shallower depth spillways is higher for the same discharge than it is for the deeper spillways. It is reasonable to assume that if the depth of the spillway causes a higher head for freeflow conditions, any effect of submergence is going to have less influence.

Because the data which were obtained in the submergence tests for a square spillway were somewhat scattered, it is questionable whether submergence will cause similar effects on the field structure. Consequently, it was decided not to spend any further time making tests of spillways having other ratios of length to width. If there are conditions in the field where it is anticipated that submerged conditions may prevail, it will no doubt be possible to use a square-shaped spillway.

Chart for Submergence Correction

In order to design a spillway for a submerged condition and still make use of the calibration data for freeflow conditions, a chart was prepared as shown in figure 15, page 26, which may be used for making a correction for determining the required design head. This chart gives, for ratios of width to depth of W = D, W = 2D, and W = 4D, the percent increase in head for various amounts of submergence and values of H/L. The procedure for using this chart in designing a spillway is to select a square-shaped spillway from the rating tables which will carry the design flow with a given head (H) above the spillway. It would be advisable to select a width equal to D, 2D, or 4D, if possible, in order to avoid interpolations on the correction chart. With the depth of tailwater above the crest elevation which it is estimated will occur in the field, the percent submergence can be estimated on the basis of the freeflow head (H) taken from the rating table. By entering the chart corresponding to the proper ratio of W to D, H/L value and submergence, the percent increase in head can be determined. This percent of the freeflow head added to the freeflow head gives the head necessary to carry the design flow with the estimated amount of tailwater. A new value of submergence could then be computed with the new value of head on the spillway and the process repeated to get a more accurate correction of the head, although such a procedure is not considered justifiable on the basis of the erratic behavior of the spillway under submerged conditions. However, it is felt that a spillway designed on the basis of the rating table and corrected for submergence according to the chart shown in figure 15 should be accurate within 5 percent, or at most, 10 percent.

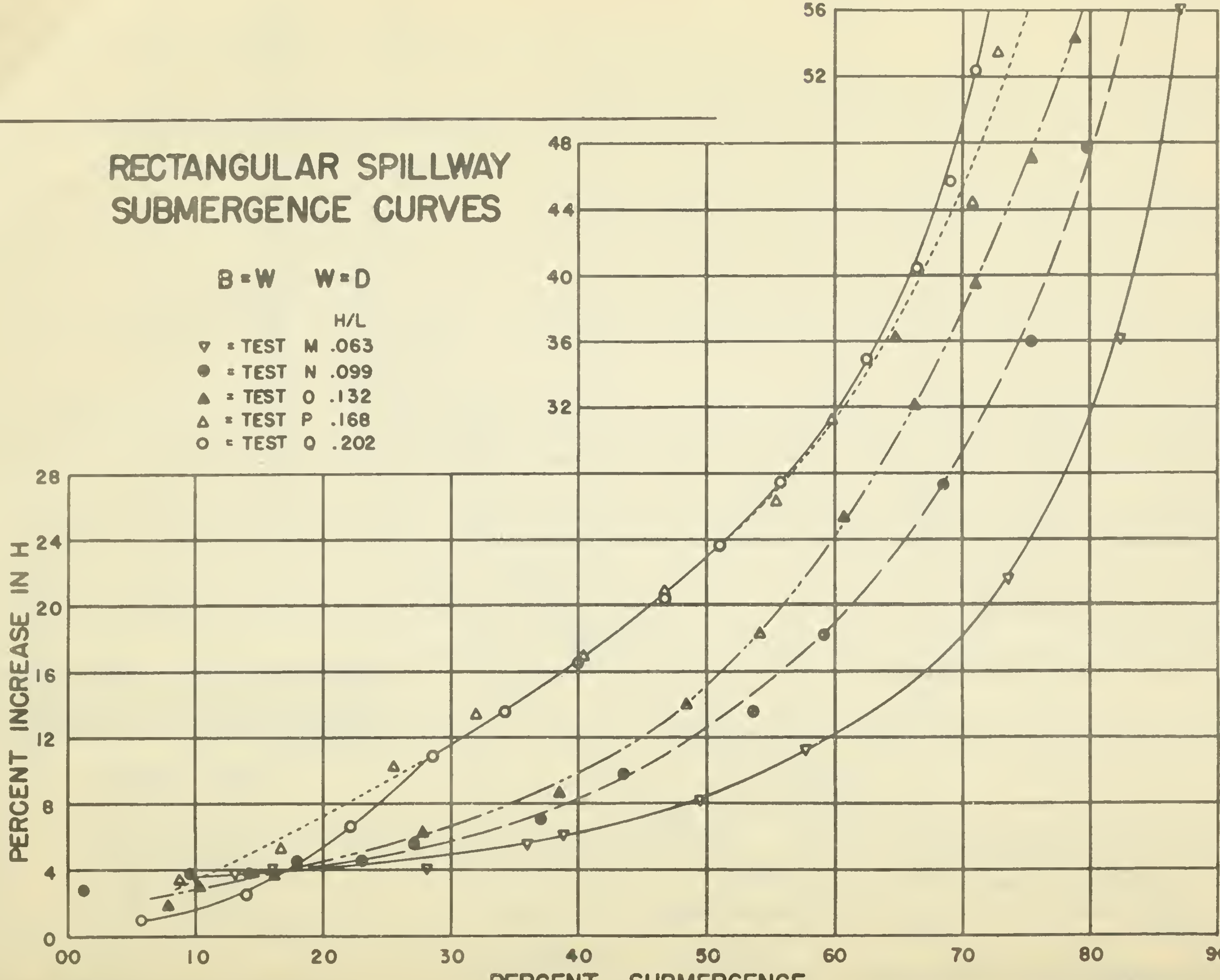

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FIGURE 12

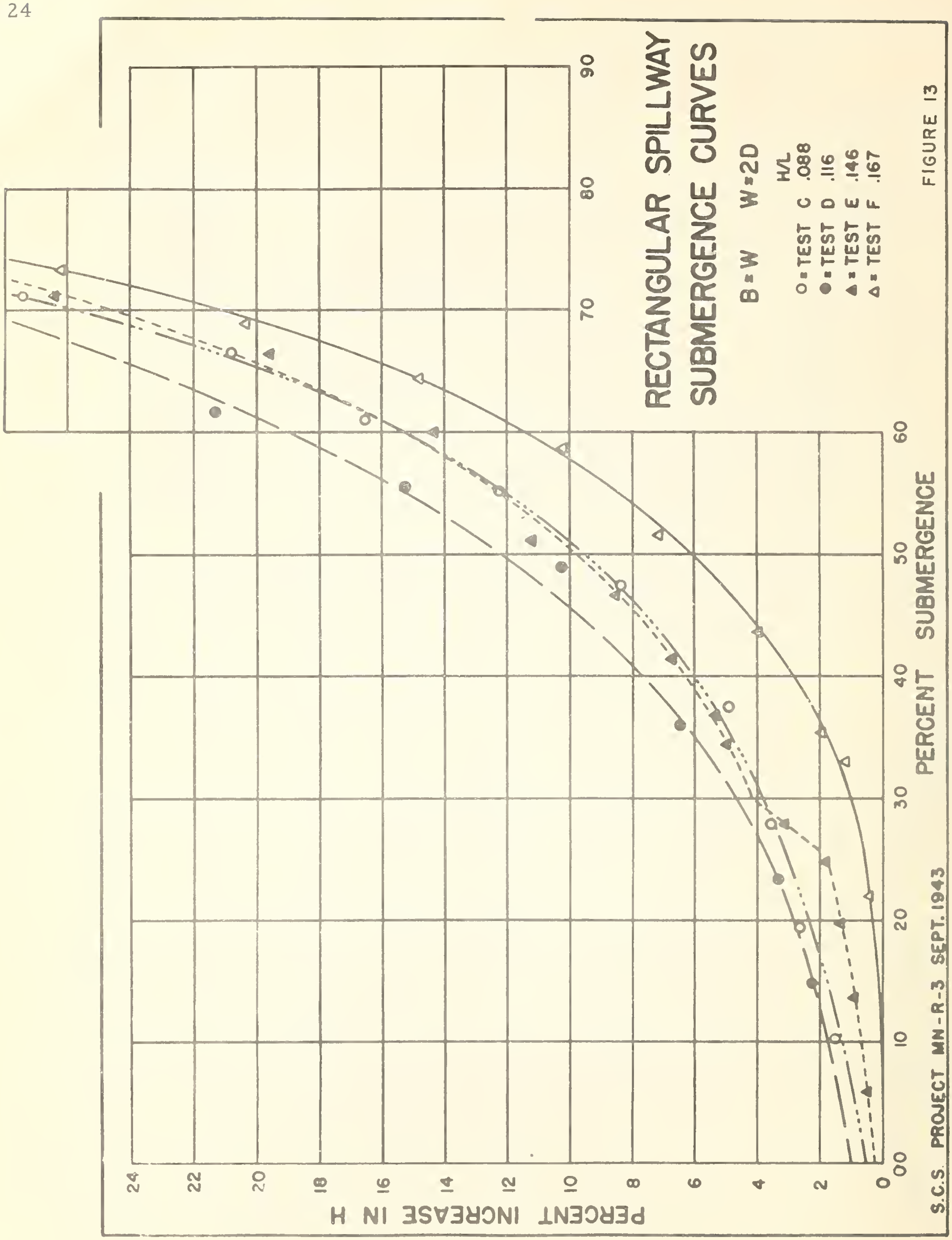
RECTANGULAR SPILLWAY
SUBMERGENCE CURVES
B = W W = 2D
H/L
○ = TEST C .088
● = TEST D .116
▲ = TEST E .146
△ = TEST F .167
PERCENT SUBMERGENCE
PERCENT INCREASE IN H
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FIGURE 13

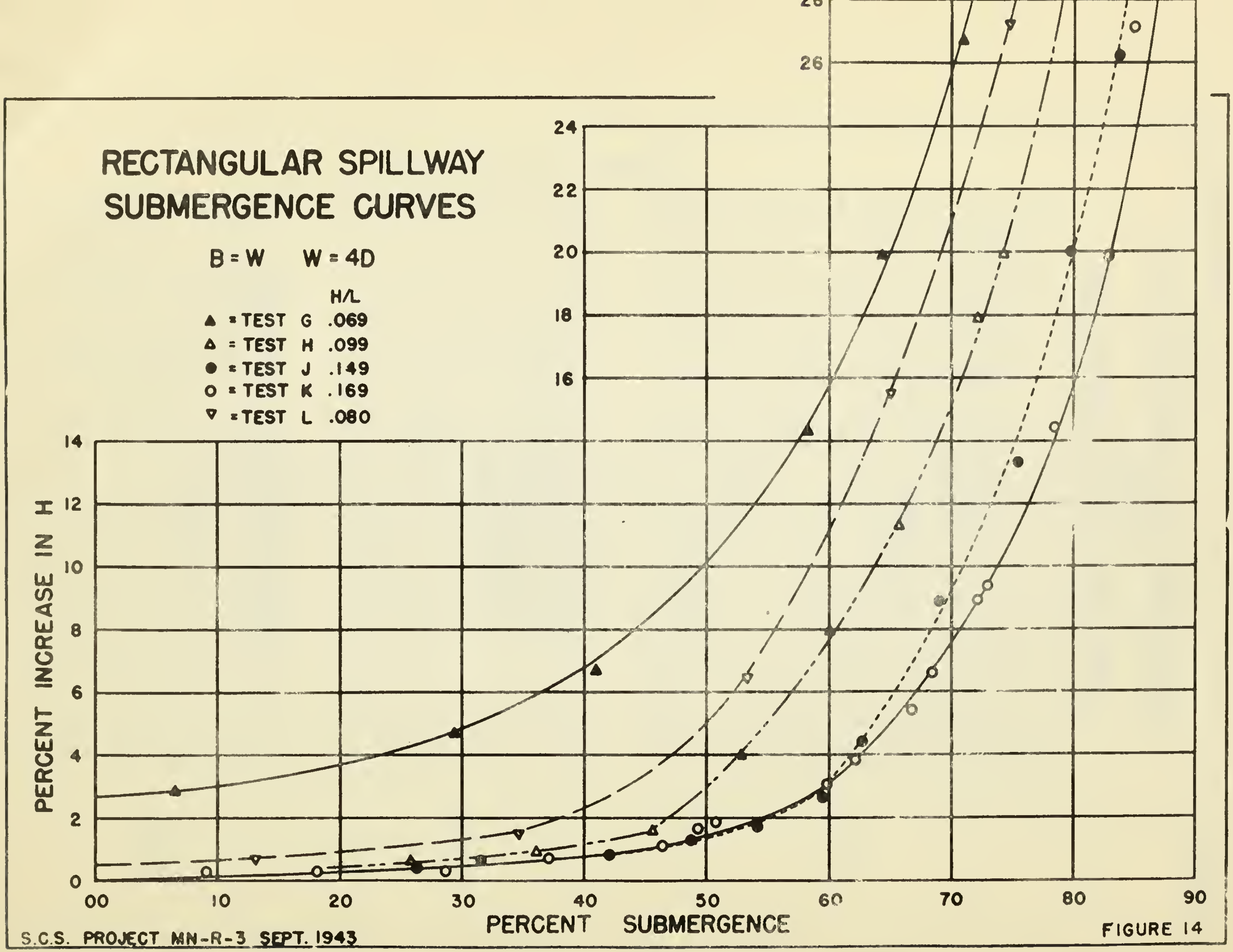
RECTANGULAR SPILLWAY
SUBMERGENCE CURVES
B = W W = 4D
H/L
▲ = TEST G .069
△ = TEST H .099
● = TEST J .149
○ = TEST K .169
▽ = TEST L .080
PERCENT INCREASE IN H
PERCENT SUBMERGENCE
0
2
4
6
8
10
12
14
16
18
20
22
24
26
00
10
20
30
40
50
60
70
80
90
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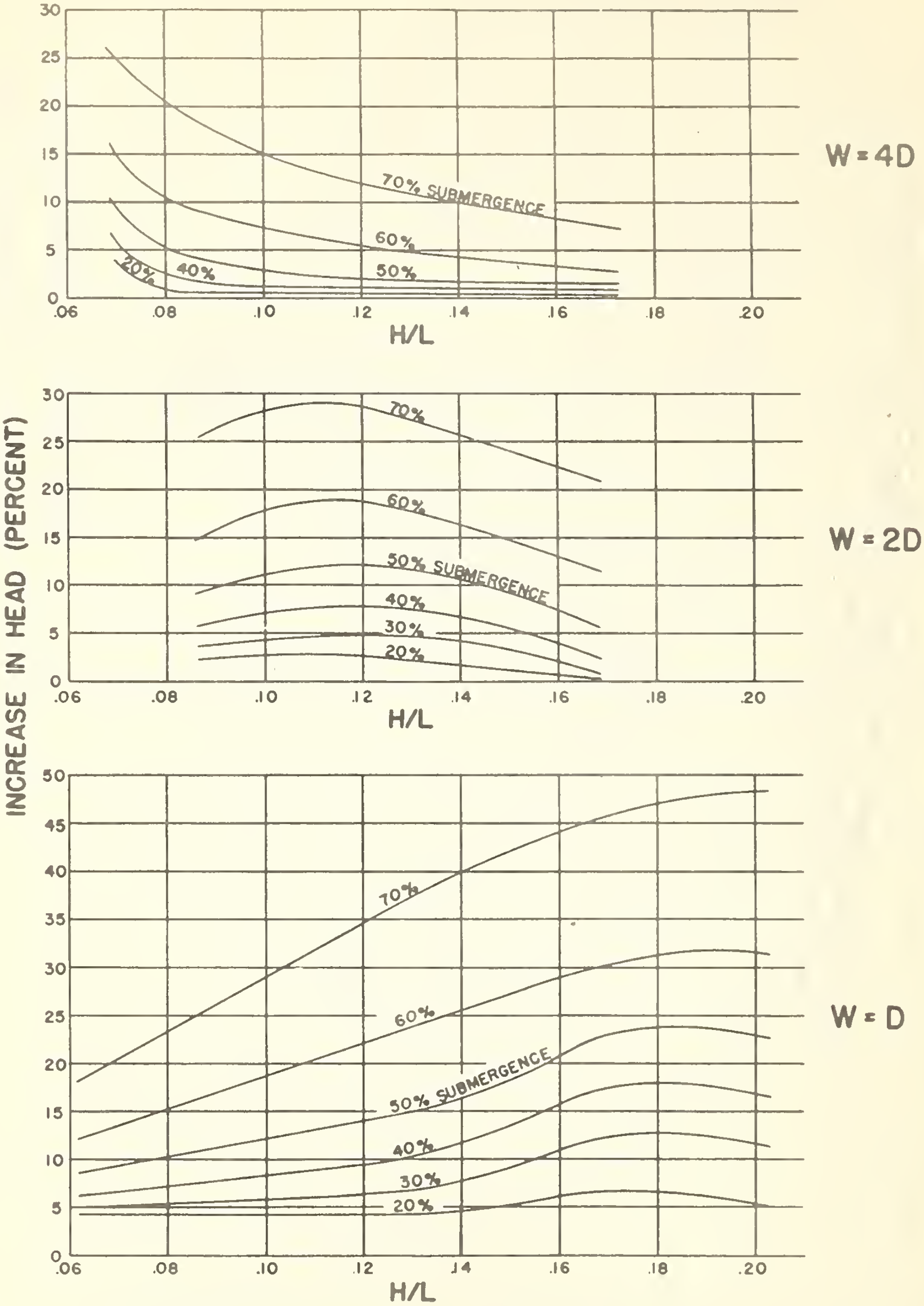
FIGURE 14



RECTANGULAR SPILLWAY
W = B
HEAD CORRECTION FOR SUBMERGENCE

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FIGURE 15

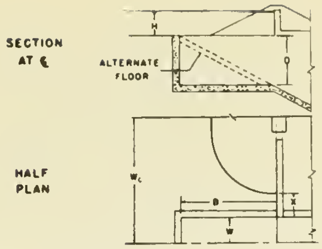
APPENDIX A

RATING TABLES

FOR

RECTANGULAR SPILLWAY

WITH OPEN-TOP OUTLET



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET

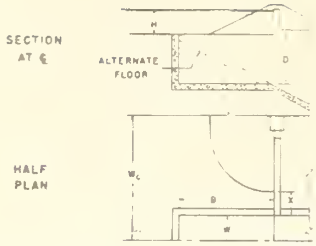
DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$, $X = H$

D = 2 FEET

W	*B*	Discharge in c. f. s.									
		Depth of water, (*H*.) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
2	1	4.8	12.9	20.7							
	2	6.6	19.0	29.0							
	3	8.2	24.3	35.6							
	4	9.8	29.0	41.3							
4	2	9.1	27.2	47.6	67.0	86.9					
	3	10.7	32.5	56.8	78.2	99.5					
	4	12.3	37.1	63.9	86.2	108					
	5	13.9	41.8	70.0	93.0						
	6	15.3	46.0	75.5	98.5						
	7	17.0	50.5	80.5	103						
	8	18.7	54.8	84.5	106						
6	2	11.3	33.6	62.0	91.5	122	154				
	3	13.2	39.7	73.0	106	138	[illegible]	202			
	4	14.9	44.8	83.0	121	154	[illegible]	222			
	5	16.1	49.0	92.0	131	165	200	235			
	6	17.8	53.6	98.5	138	173	208	243			
	7	19.4	[illegible]	105	144	[illegible]					
	8	20.8	62.0	110	148	[illegible]					
	9	22.8	67.0	115	[illegible]						
	10	24.0	71.2	119	153						
	12	27.4	81.0	124	155						
8	2	13.1	39.1	73.8	114	[illegible]	203	251	302		
	3	15.3	45.8	86.5	130	[illegible]	217	263	310		
	4	17.2	51.6	98.5	144	186	231	275	321		
	5	19.0	56.5	107	157	199	244	288	332		
	6	20.5	61.0	117	169	211	258	300	344		
	7	21.8	65.5	125	180	225	270	315	360		
	8	23.2	69.8	133	190	237	284	332	378		
	9	24.6	74.0	139	196						
	10	26.2	78.0	145	201						
	12	29.1	86.0	153	205						
	14	32.2	94.5	159	205						
	16	35.5	103	162	205						



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET

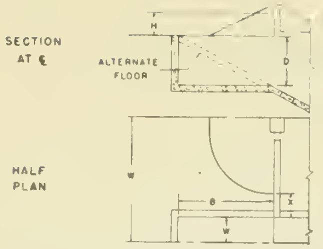
DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W+2B)$; $X = H$

D = 3 FEET

W	B	Discharge in c. f. s.									
		Depth of water, (H,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
4	2	9.1	27.2	48.8	71.5						
	4	12.3	37.1	69.5	100						
	6	15.3	46.0	88.0	122						
	8	18.7	55.2	104	140	170					
6	2	11.3	33.6	63.0	95.0	127	160				
	4	14.9	44.8	85.0	128	168	205				
	6	17.8	53.6	102	153	199	238				
	8	20.8	62.0	119	175	223	263				
	10	24.0	71.2	135	195	242	282				
	12	27.4	81.0	152	212	254	293				
8	2	13.1	39.1	73.8	114	157	203				
	4	17.2	51.6	98.5	152	205	256				
	6	20.5	61.0	117	182	245	300				
	8	23.2	69.8	133	204	278	335				
	10	26.2	78.0	149	226	302	360				
	12	29.1	87.0	165	245	320	375				
	14	32.2	96.0	180	262	330	383				
	16	35.5	106	197	276	335	383				
10	4	19.4	58.0	111	175	235	303				
	6	22.9	68.5	132	206	282	354				
	8	25.9	77.5	148	233	320	397				
	10	28.6	85.5	163	256	355	430				
	12	31.4	94.0	179	280	380	450				
	14	34.3	103	193	298	395	463				
	16	37.3	111	208	315	405	470				
	18	40.5	120	224	328	410	472				
	20	43.8	130	240	340	412	474				
12	4	21.4	64.0	121	190	265	342	420	500	584	670
	6	25.1	75.0	142	225	312	397	475	555	639	722
	8	28.3	84.5	161	253	356	446	525	610	695	780
	10	31.1	93.0	176	280	395	490	570	655	745	825
	12	33.9	101	192	303	427	524	613	697	784	865
	14		109	206	325	448	543				
	16		118	221	344	460	558				
	18		126	236	362	470	562				
	20		136	252	378	478	564				
	24		155	284	403	486	564				



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET
DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE
$W_c = 1.5(W+2B)$; $X = H$
D = 4 FEET

W	*B*	Discharge in c. f. s.									
		Depth of water, (*H*,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
4	2	9.1	27.2	49.6	73.1	94.8	117				
	4	12.3	37.1	70.5	107	140	170				
	6	15.3	46.0	87.5	138	173	206				
	8	18.7	55.2	104	164	198	234				
6	2	11.3	33.6	63.0	95.0	129	163				
	4	14.9	44.8	85.0	132	174	217	259			
	6	17.8	53.6	102	158	211	262	311			
	8	20.8	62.0	119	183	245	300	350			
	10	24.0	71.2	135	209	278	330				
	12	27.4	81.0	152	238	310	358				
8	2	13.1	39.1	73.8	114	157	203	251	302		
	4	17.2	51.6	98.5	154	212	270	324	379	434	492
	6	20.5	61.0	117	184	252	320	380	438	500	560
	8	23.2	69.8	133	210	286	362	427	488	552	612
	10	26.2	78.0	149	235	320	398	464	520	595	
	12	29.1	87.0	165	260	350	427	497	552		
	14	32.2	96.0	181	285	380	453	523	580		
	16	35.5	106	199	312	411	478	545	602		
10	4	19.4	58.0	111	175	244	312	382	452	520	
	6	22.9	68.5	132	206	290	370	448	522	598	675
	8	25.9	77.5	148	233	328	420	500	580	660	740
	10	28.6	85.5	163	256	360	462	550	630	720	795
	12	31.4	94.0	179	280	390	495	580	665		
	14	34.3	103	195	305	420	520	610	690		
	16	37.3	111	211	330	450	550	630	715		
	18	40.5	120	228	355	480	570	655	730		
	20	43.8	130	246	382	505	590	670	745		
12	4	21.4	64.0	121	190	270	350	433	518	605	695
	6	25.1	75.0	142	225	320	412	506	596	687	778
	8	28.3	84.5	160	253	360	468	570	665	760	850
	10	31.1	93.0	176	280	400	515	622	730	830	920
	12	33.9	101	192	303	431	557	669	780	887	978
	14		109	208	328	462	590	700	820		
	16		118	223	350	490	620	730	845		
	18		126	240	375	520	645	750	865		
	20		136	256	400	545	665	770	875		
	24		155	291	450	595	700	800	885		

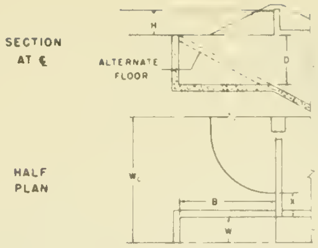
RECTANGULAR SPILLWAY

Discharge Table

D = 4 feet

(Continued)

W	*B*	Discharge in c. f. s.									
		Depth of water *(H.)* in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
14	4	23.5	69.0	131	206	292	388	485	582	685	795
	6	27.5	81.0	154	244	345	454	570	670	775	880
	8	30.8	91.0	173	275	390	510	640	750	860	960
	10	33.8	100	190	300	430	565	700	815	930	1040
	12	36.4	108	206	326	465	610	750	870	990	1100
	14	39.0	116	221	350	500	655	800	920	1050	1160
	16		124	235	375	530	690	835	955		
	18		133	252	400	560	720	865	980		
	20		140	267	420	590	740	890	1000		
	24		158	300	470	640	780	910	1025		
	28		177	336	520	685	810	920	1030		
16	4	25.2	74.4	141	221	314	418	528	643	761	888
	6	29.5	87.0	165	260	370	485	610	740	860	970
	8	33.0	97.5	186	292	417	548	688	820	940	1060
	10	36.0	107	204	320	460	605	760	900	1020	1140
	12	39.0	115	220	348	495	660	820	965	1080	1200
	14	41.5	124	235	370	530	705	880	1020	1150	1280
	16	44.1	131	250	395	563	751	927	1075	1205	1341
	18		139	265	420	595	780	960	1100		
	20		147	280	440	620	810	985	1120		
	24		164	312	490	675	860	1015	1140		
	28		180	345	530	725	895	1030	1150		
	32		201	381	584	775	914	1037	1158		



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE
$W_c = 1.5(W+2B),\ X = H$

D = 5 FEET

W	*B*	Discharge in c. f. s.									
		Depth of water, (*d*,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
6	2	11.3	33.6	63.0	95.0	130	165				
	4	14.9	44.8	85.0	132	180	228	276			
	6	17.8	53.6	102	160	220	282	341			
	8	20.8	62.0	119	186	259	330	395			
	10	24.0	71.2	135	212	300	372	438			
	12	27.4	81.0	152	238	342	410	468			
8	2	13.1	39.1	73.8	114	157	203	251	302		
	4	17.2	51.6	98.5	154	214	278	334	399		
	6	20.5	61.0	117	184	255	332	405	478		
	8	23.2	69.8	133	210	293	380	465	540		
	10	26.2	78.0	149	235	328	425	520	595		
	12	29.1	87.0	165	260	364	468	570	640		
	14	32.2	96.0	181	285	405	510	605	675		
	16	35.5	106	199	312	443	550	630	705		
10	4	19.4	58.0	111	175	244	316	388	467	545	
	6	22.9	68.5	132	206	290	378	465	555	640	
	8	25.9	77.5	148	233	328	430	530	620	720	
	10	28.6	85.5	163	256	363	478	588	685	790	
	12	31.4	94.0	179	280	398	525	635	735	845	
	14	34.3	103	195	305	430	570	680	780	890	
	16	37.3	111	211	330	465	610	720	820	930	
	18	40.5	120	228	358	500	645	755	850	950	
	20	43.8	130	246	385	542	686	786	880	969	
12	4	21.4	64.0	121	190	270	354	438	528	620	710
	6	25.1	75.0	142	225	320	421	521	620	725	820
	8	28.3	84.5	160	253	362	478	590	705	815	915
	10	31.1	93.0	176	280	400	528	650	775	890	995
	12	33.9	101	192	303	432	570	703	835	955	1060
	14		109	208	328	465	610	755	890	1010	1120
	16		118	223	350	500	650	800	935	1055	1160
	18		126	240	377	530	695	840	975	1090	1200
	20		136	256	403	568	735	875	1005	1120	1220
	24		155	291	458	640	815	935	1045	1150	1250
14	4	23.5	69.0	131	206	292	388	488	588	690	800
	6	27.5	81.0	154	244	345	460	575	690	805	910
	8	30.8	91.0	173	275	390	515	650	775	900	1020
	10	33.8	100	190	300	430	565	720	850	990	1105

RECTANGULAR SPILLWAY

Discharge Table

D = 5 Feet

(Continued)

W	*B*	Discharge in c. f. s.									
		Depth of water, *(H,)* in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
14	12	36.4	108	206	326	465	610	780	920	1060	1190
	14	39.0	116	221	350	500	658	828	983	1130	1260
	16		124	235	375	535	700	880	1035	1180	1310
	18		133	252	400	565	740	825	1080	1225	1350
	20		140	267	425	600	780	970	1110	1260	1380
	24		158	300	477	665	860	1040	1170	1310	1425
	28		177	336	531	740	940	1090	1210	1340	1450
16	4	25.2	74.4	141	221	314	418	528	643	761	888
	6	29.5	87.0	165	260	370	490	620	750	880	1015
	8	33.0	97.5	186	292	417	551	698	840	985	1120
	10	36.0	107	204	320	460	610	770	930	1080	1230
	12	39.0	115	220	348	495	655	830	1000	1160	1310
	14	41.5	124	235	370	530	705	890	1070	1240	1390
	16	44.1	131	250	395	563	751	940	1135	1300	1455
	18		139	265	420	595	795	990	1190	1360	1510
	20		147	280	440	625	835	1040	1230	1400	1550
	24		164	312	495	690	915	1110	1300	1460	1600
	28		180	345	545	755	990	1180	1350	1490	1620
	32		200	381	597	830	1060	1235	1370	1510	1640
18	6	31.2	93.0	176	276	395	525	670	800	940	1100
	8	35.0	104	196	310	440	590	750	900	1050	1230
	10	38 2	114	215	340	485	645	825	995	1150	1330
	12	41.2	123	232	368	525	695	890	1080	1250	1420
	14	44.0	132	250	392	560	745	950	1155	1335	1510
	16	46.5	140	265	415	595	790	1010	1230	1410	1590
	18	49.0	147	279	440	625	836	1060	1295	1490	1660
	20		155	295	463	660	875	1110	1350	1540	1710
	24		172	325	510	720	950	1200	1430	1600	1760
	28		190	358	560	785	1030	1270	1490	1650	1800
	32		207	390	615	860	1100	1330	1520	1670	1830
	36		225	427	667	925	1180	1380	1530	1690	1840
20	6		98.0	186	292	416	555	705	860	1020	1190
	8		110	208	328	465	620	790	960	1130	1320
	10		120	228	360	510	680	870	1050	1235	1430
	12		129	245	390	550	735	940	1140	1330	1530
	14		138	262	415	590	785	1000	1230	1420	1640

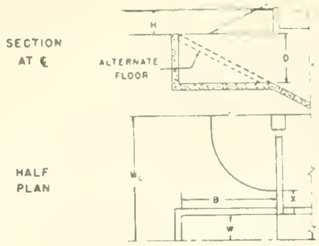
RECTANGULAR SPILLWAY

Discharge Table

D = 5 Feet

(Continued)

W	*B*	Discharge in c. f. s.									
		Depth of water, (*H*.) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
20	16		146	278	440	620	830	1065	1300	1510	1730
	18		155	293	463	660	880	1120	1385	1590	1800
	20		162	307	485	690	920	1179	1450	1650	1870
	24		178	338	530	755	1000	1280	1540	1730	1950
	28		195	370	580	820	1080	1350	1590	1780	1980
	32		212	400	630	885	1150	1420	1640	1810	2000
	36		230	432	680	950	1230	1480	1660	1840	2020
	40		248	467	735	1020	1294	1519	1668	1852	2024



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE
$W_c = 1.5(W+2B),\ X = H$

D = 6 FEET

W	B	Discharge in c. f. s.									
		Depth of water, *(d.)* in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
6	2	11.3	33.6	63.0	95.0	131	167				
	4	14.9	44.8	85.0	132	184	235	285	330		
	6	17.8	53.6	102	160	228	296	358	414		
	8	20.8	62.0	119	186	270	352	422	478		
	10	24.0	71.2	135	212	307	405	475	540		
	12	27.4	81.0	152	238	342	452	519	581		
8	2	13.1	39.1	73.8	114	157	203	251	302		
	4	17.2	51.6	98.5	154	215	280	340	408		
	6	20.5	61.0	117	184	260	330	420	495		
	8	23.2	69.8	133	210	296	390	483	570		
	10	26.2	78.0	149	235	333	440	545	640		
	12	29.1	87.0	165	260	370	488	600	700		
	14	32.2	96.0	181	285	406	540	650	750		
	16	35.5	106	199	312	443	590	700	795		
10	4	19.4	58.0	111	175	244	320	395	475		
	6	22.9	68.5	132	206	290	384	475	570		
	8	25.9	77.5	148	233	330	438	542	650		
	10	28.6	85.5	163	256	366	485	605	718		
	12	31.4	94.0	179	280	400	530	660	775		
	14	34.3	103	195	305	435	575	715	835		
	16	37.3	111	211	330	470	620	770	890		
	18	40.5	120	228	358	510	665	820	940		
	20	43.8	130	246	385	546	720	875	1000		
12	4	21.4	64.0	121	190	270	354	445	538	625	720
	6	25.1	75.0	142	225	320	424	530	636	744	845
	8	28.3	84.5	160	253	362	480	600	720	840	950
	10	31.1	93.0	176	280	400	530	665	800	920	1040
	12	33.9	101	192	303	433	578	721	864	997	1122
	14		109	208	328	467	620	775	930	1060	1180
	16		118	223	350	500	660	830	990	1130	1250
	18		126	240	377	535	710	880	1050	1180	1300
	20		136	256	403	570	755	930	1100	1230	1350
	24		155	291	458	645	854	1049	1200	1317	1429
14	4	23.5	69.0	131	206	292	388	490	590	700	810
	6	27.5	81.0	154	244	345	460	580	700	825	940
	8	30.8	91.0	173	275	390	520	655	790	930	1050
	10	33.8	100	190	300	430	570	725	880	1020	1150

RECTANGULAR SPILLWAY

Discharge Table

D = 6 Feet

(Continued)

W Feet	*B* Feet	Discharge in c. f. s. Depth of water (H_1) in feet 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
14	12	36.4	108	206	326	465	620	780	950	1100	1250
	14	39.0	116	221	350	500	660	840	1020	1170	1330
	16		124	235	375	535	705	890	1080	1230	1400
	18		133	252	400	570	750	940	1140	1300	1460
	20		140	267	425	600	790	1000	1200	1350	1520
	24		158	300	477	670	880	1100	1300	1440	1600
	28		177	336	531	747	980	1205	1390	1520	1650
16	4	25.2	74.4	141	221	314	418	528	643	761	888
	6	29.5	87.0	165	260	370	490	620	760	890	1030
	8	33.0	97.5	186	292	417	553	703	855	1005	1155
	10	36.0	107	204	320	460	610	775	940	1100	1260
	12	39.0	115	220	348	495	660	840	1020	1190	1360
	14	41.5	124	235	370	530	705	900	1100	1280	1450
	16	44.1	131	250	395	563	751	950	1160	1350	1540
	18		139	265	420	600	790	1005	1230	1420	1600
	20		147	280	440	630	830	1060	1290	1480	1660
	24		164	312	495	700	920	1160	1400	1580	1760
	28		180	345	545	770	1010	1260	1500	1660	1830
	32		200	381	597	848	1115	1360	1580	1720	1870
18	6	31.2	93	176	276	395	525	670	815	960	1100
	8	35	104	196	310	440	590	750	915	1080	1240
	10	38.2	114	215	340	485	645	825	1000	1190	1350
	12	41.2	123	232	368	525	695	890	1080	1290	1470
	14	44	132	250	392	560	745	950	1160	1380	1580
	16	46.5	140	265	415	595	790	1010	1230	1460	1660
	18	49.0	147	279	440	625	836	1067	1304	1536	1752
	20		155	295	463	660	880	1130	1360	1610	1820
	24		172	325	510	725	960	1230	1460	1720	1930
	28		190	358	560	800	1050	1340	1570	1800	2000
	32		207	390	615	870	1140	1430	1650	1870	2060
	36		225	427	667	946	1240	1520	1750	1925	2100
20	6		98	186	292	416	555	705	870	1025	1190
	8		110	208	328	465	620	790	970	1140	1330
	10		120	228	360	510	680	870	1060	1260	1460
	12		129	245	390	550	735	940	1140	1350	1580
	14		138	262	415	590	785	1000	1220	1450	1690

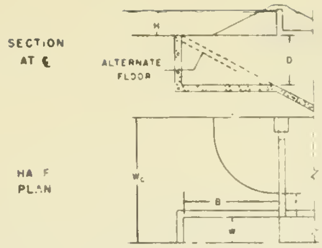
RECTANGULAR SPILLWAY

Discharge Table

D = 6 Feet

(Continued)

W Feet	*B* Feet	Discharge in c. f. s. Depth of water, (*H*.) in feet 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
20	16		146	278	440	620	830	1065	1300	1540	1790
	18		155	293	463	660	880	1125	1370	1620	1870
	20		162	307	485	690	920	1179	1450	1700	1965
	24		178	338	530	755	1010	1280	1570	1820	2080
	28		195	370	580	825	1090	1380	1680	1920	2170
	32		212	400	630	900	1180	1480	1780	2000	2240
	36		230	432	680	965	1270	1570	1850	2060	2290
	40		248	467	735	1044	1360	1670	1930	2120	2315
24	6		109	205	324	457	610	778	956	1151	1352
	8		122	230	362	510	685	870	1070	1290	1490
	10		132	250	397	560	745	950	1170	1400	1640
	12		142	269	424	603	804	1030	1265	1510	1765
	14		150	285	452	640	860	1100	1340	1620	1900
	16		159	302	480	680	905	1160	1420	1720	2030
	18		168	318	503	715	955	1230	1500	1810	2150
	20		175	332	528	745	1000	1280	1560	1900	2250
	24		191	362	572	817	1089	1391	1716	2060	2414
	28			390	615	880	1155	1500	1830	2180	2550
	32			422	665	950	1240	1590	1940	2300	2640
	36			453	715	1020	1330	1690	2040	2380	2700
	40			485	765	1080	1410	1780	2120	2450	2750
	44			520	820	1160	1500	1870	2200	2490	2750
	48			553	876	1233	1609	1964	2285	2520	2750



RECTANGULAR SPILLWAY
WITH
OPEN-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W+2B),\ X = H$

D = 8 FEET

W	R	Discharge in c. f. s.									
		Depth of water, (H,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
8	2	13.1	39.1	73.8	114	157	203	251	302		
	4	17.2	51.6	98.5	154	215	280	347	410	475	535
	6	20.5	61.0	117	184	260	343	430	517	595	670
	8	23.2	69.8	133	210	298	398	500	610	705	790
	10	26.2	78.0	149	235	339	450	570	695	800	890
	12	29.1	87.0	165	260	375	500	630	770	890	975
	14	32.2	96.0	181	285	410	548	695	855	970	1050
	16	35.5	106	199	312	443	592	760	930	1040	1120
10	4	19.4	58.0	111	175	244	320	400	480	565	640
	6	22.9	68.5	132	206	290	385	480	585	685	775
	8	25.9	77.5	148	233	330	440	555	665	790	890
	10	28.6	85.5	163	256	366	488	620	750	890	1000
	12	31.4	94.0	179	280	400	535	685	830	980	1100
	14	34.3	103	195	305	435	585	750	910	1065	1190
	16	37.3	111	211	330	470	630	810	980	1150	1280
	18	40.5	120	228	358	510	682	870	1065	1230	1360
	20	43.8	130	246	385	545	727	923	1144	1300	1450
12	4	21.4	64.0	121	190	270	354	445	540	640	735
	6	25.1	75.0	142	225	320	424	535	648	770	871
	8	28.3	84.5	160	253	362	480	610	720	880	998
	10	31.1	93.0	176	280	400	530	675	820	978	1110
	12	33.9	101	192	303	433	578	735	893	1055	1205
	14		109	208	328	467	625	800	968	1150	1310
	16		118	223	350	505	670	855	1040	1230	1400
	18		126	240	377	538	715	915	1120	1320	1500
	20		136	256	403	572	760	970	1200	1490	1580
			155	291	458	645	860	1090	1360	1560	1750
14	4	23.5	69.0	131	206	292	388	490	592	704	818
	6	27.5	81.0	154	244	345	460	580	705	843	977
	8	30.8	91.0	173	275	390	520	655	800	960	1100
	10	33.8	100	190	300	430	570	725	882	1070	1210
	..	36.4	108	206	326	465	620	790	960	1115	1310
	14	39.0	116	221	350	500	660	850	1035	1230	1420
	16		124	235	375	533	705	905	1100	1310	1500
	18		133	252	400	569	750	965	1155	1400	1600
	20		140	267	425	600	795	1025	1250	1475	1690
	24		158	300	477	672	890	1140	1400	1640	1860
	28		177	336	531	747	993	1260	1570	1820	2040

RECTANGULAR SPILLWAY

Discharge Table

D = 8 Feet

(Continued)

W	B	Discharge in c. f. s.									
		Depth of water, *(H,)* in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
16	4	25.2	74.4	141	221	314	418	528	643	761	888
	6	29.5	87.0	165	260	370	490	625	664	909	1050
	8	33.0	97.5	186	292	417	556	712	870	1045	1190
	10	36.0	107	204	320	460	610	780	960	1180	1310
	12	39.0	115	220	348	495	660	845	1030	1230	1420
	14	41.5	124	235	370	530	705	905	1120	1320	1520
	16	44.1	131	250	395	563	751	959	1187	1403	1621
	18		139	265	420	600	800	1020	1260	1490	1710
	20		147	280	440	630	840	1080	1330	1570	1800
	24		164	312	495	700	930	1190	1460	1730	1980
	28		180	345	545	770	1030	1310	1610	1790	2150
	32		200	381	597	848	1126	1430	1776	2062	2325
18	6	31.2	93.0	176	276	395	525	670	820	990	1130
	8	35.0	104	196	310	440	590	750	925	1120	1280
	10	38.2	114	215	340	485	645	825	1010	1220	1400
	12	41.2	123	232	368	525	695	890	1090	1320	1520
	14	44.0	132	250	392	560	745	950	1160	1400	1630
	16	46.5	140	265	415	595	790	1000	1230	1490	1740
	18	49.0	147	279	440	625	836	1067	1304	1575	1840
	20		155	295	463	660	880	1120	1360	1650	1930
	24		172	325	510	725	960	1240	1500	1800	2120
	28		190	358	560	800	1065	1350	1640	1960	2280
	32		207	390	615	870	1160	1470	1800	2130	2440
	36		225	427	667	946	1263	1603	1973	2300	2590
20	6		98.0	186	292	416	555	705	864	1035	1200
	8		110	208	328	465	620	790	970	1180	1360
	10		120	228	360	510	680	870	1070	1300	1500
	12		129	245	390	550	735	940	1150	1390	1620
	14		138	262	415	590	785	1000	1230	1480	1740
	16		146	278	440	620	830	1065	1300	1560	1850
	18		155	293	463	660	880	1125	1370	1650	1950
	20		162	307	485	690	920	1179	1450	1747	2040
	24		178	338	530	755	1010	1290	1600	1900	2200
	28		195	370	580	825	1100	1400	1740	2050	2380
	32		212	400	630	900	1200	1510	1880	2200	2550
	36		230	432	680	965	1300	1630	2025	2350	2700
	40		248	467	735	1044	1393	1768	2176	2530	2850

RECTANGULAR SPILLWAY

Discharge Table

D = 8 Feet

(Continued)

W	B	Discharge in c. f. s.									
		Depth of water, (*H*,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
24	6		109	205	324	457	610	778	956	1151	1352
	8		122	230	362	510	685	870	1070	1290	1520
	10		132	250	397	560	745	950	1160	1410	1650
	12		142	269	424	603	804	1030	1270	1530	1795
	14		150	285	452	640	860	1100	1350	1630	1910
	16		159	302	480	680	905	1160	1430	1720	2030
	18		168	318	503	715	955	1230	1500	1800	2150
	20		175	332	528	745	1000	1280	1575	1900	2250
	24		191	362	572	817	1089	1391	1716	2060	2447
	28		207	390	615	880	1175	1500	1850	2210	2610
	32		223	422	665	950	1265	1620	1990	2370	2790
	36			453	715	1020	1355	1730	2120	2530	2950
	40			485	765	1080	1445	1840	2250	2680	3100
	44			520	820	1160	1545	1960	2400	2840	3200
	48			553	876	1233	1640	2080	2550	2980	3380
28	8		133	250	390	560	740	950	1150	1400	1650
	10		144	272	425	610	800	1030	1260	1550	1830
	12		154	292	460	650	865	1110	1360	1660	1960
	14		164	310	487	693	920	1190	1460	1775	2060
	16		173	328	512	730	970	1250	1540	1880	2200
	18		181	343	540	765	1025	1310	1610	1970	2320
	20		190	360	565	800	1070	1370	1690	2060	2420
	24		205	390	610	875	1160	1490	1840	2210	2600
	28		220	419	658	940	1250	1600	1980	2360	2800
	32			450	700	1000	1340	1710	2120	2510	2960
	36			480	750	1070	1430	1820	2250	2650	3130
	40			510	800	1140	1520	1930	2400	2800	3300
	44			540	850	1200	1610	2050	2540	2950	3450
	48			575	900	1280	1700	2170	2670	3100	3600
	52			610	950	1350	1790	2280	2800	3250	3750
	56			643	1002	1427	1891	2400	2930	3400	3880

RECTANGULAR SPILLWAY

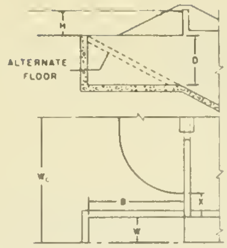
Discharge Table

D = 8 Feet

(Continued)

P	*B*	Discharge in c. f. s.									
		Depth of water, *(H,)* in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
32	8		131	268	421	598	798	1012	1252	1508	1776
	10		145	292	460	650	870	1110	1370	1650	1930
	12		156	314	492	700	940	1190	1460	1780	2080
	14		168	332	525	745	1000	1270	1550	1900	2230
	16		178	350	552	787	1045	1340	1650	2000	2360
	18		188	370	580	830	1100	1410	1730	2100	2470
	20		200	385	605	860	1150	1475	1800	2200	2600
	24		216	415	655	930	1250	1600	1950	2370	2800
	28		234	445	700	1000	1340	1700	2100	2540	3000
	32		250	473	744	1063	1417	1810	2235	2694	3188
	36				790	1120	1500	1920	2360	2830	3350
	40				840	1180	1580	2030	2500	2980	3500
	44				880	1250	1670	2140	2640	3130	3680
	48				930	1320	1750	2250	2760	3280	3820
	52				980	1380	1850	2360	2900	3400	3980
	56				1025	1460	1950	2480	3020	3560	4100
	60				1075	1530	2050	2600	3170	3700	4250
	64				1136	1613	2153	2724	3302	3849	4383

SECTION AT ℄



HALF PLAN

RECTANGULAR SPILLWAY WITH OPEN-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$; $X = H$

D = 10 FEET

W	B	Discharge in c. f. s. Depth of water, (H,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
10	4	19.4	58.0	111	175	244	320	400	482	570	645
	6	22.9	68.5	132	206	291	385	488	588	690	800
	8	25.9	77.5	148	233	330	440	560	680	810	930
	10	28.6	85.5	163	256	366	488	625	766	914	1060
	12	31.4	94.0	179	280	400	535	690	845	1020	1180
	14	34.3	103	195	305	435	585	750	920	1115	1290
	16	37 3	111	211	330	470	630	810	1000	1200	1400
	18	40.5	120	228	358	510	682	870	1070	1290	1510
	20	43.8	130	246	385	546	727	923	1144	1384	1621
12	4	21.4	64.0	121	190	270	354	445	540	640	740
	6	25.1	75.0	142	225	320	424	535	650	770	890
	8	28.3	84.5	160	253	362	480	610	740	880	1030
	10	31.1	93.0	176	280	400	530	675	830	990	1150
	12	33.9	101	192	303	433	578	735	905	1080	1270
	14		109	208	328	467	625	800	980	1180	1380
	16		118	223	350	505	670	855	1060	1270	1500
	18		126	240	377	538	715	915	1130	1360	1600
	20		136	256	403	572	760	970	1200	1460	1700
	24		155	291	458	645	860	1090	1360	1645	1915
14	4	23.5	69.0	131	206	292	388	490	595	700	814
	6	27.5	81.0	154	244	345	460	580	710	840	980
	8	30.8	91.0	123	275	390	520	655	800	960	1120
	10	33.8	100	190	300	430	570	725	890	1060	1250
	12	36.4	108	206	326	465	620	790	965	150	1370
	14	39.0	116	221	350	500	660	850	1045	1245	1480
	16		124	235	375	535	705	905	1110	1340	1600
	18		133	252	400	570	750	965	1180	1420	1700
	20		140	267	425	600	795	1025	1250	1510	1800
	24		158	300	477	670	890	1140	1400	1700	2000
	28		177	336	531	747	993	1270	1570	1900	2210
16	4	25.2	74.4	141	221	314	418	528	643	761	888
	6	29.5	87.0	165	260	370	490	625	765	910	1060
	8	33.0	97.5	186	292	417	556	712	870	1045	1210
	10	36.0	107	204	320	460	610	780	955	1140	1340
	12	39.0	115	220	348	495	660	845	1035	1230	1450
	14	41.5	124	235	370	530	705	905	1105	1320	1570
	16	44.1	131	250	395	563	751	959	1187	1407	1675
	18		139	265	420	600	800	1020	1250	1490	1780

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

(Continued)

W	B	Discharge in c. f. s.									
		Depth of water, $(H,)$ in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
16	20		147	280	440	630	840	1080	1330	1570	1885
	24		164	312	495	700	930	1190	1490	1750	2090
	28		180	345	545	770	1030	1310	1630	1940	2290
	32		200	381	597	848	1126	1430	1776	2150	2500
18	6	31.2	93	176	276	395	525	670	825	980	1140
	8	35	104	196	310	440	590	750	930	1110	1300
	10	38.2	114	215	340	485	645	825	1015	1230	1440
	12	41.2	123	232	368	525	695	890	1090	1320	1560
	14	44	132	250	392	560	745	950	1165	1410	1670
	16	46.5	140	265	415	595	790	1000	1230	1500	1770
	18	49	147	279	440	625	836	1067	1304	1575	1870
	20		155	295	463	660	880	1120	1360	1650	1970
	24		172	325	510	725	960	1240	1500	1830	2150
	28		190	358	560	800	1065	1350	1650	2000	2350
	32		207	390	615	870	1160	1470	1800	2200	2550
	36		225	427	667	946	1263	1603	1973	2390	2780
20	6		98	186	292	416	555	705	870	1050	1220
	8		110	208	328	465	620	790	980	1190	1390
	10		120	228	360	510	680	870	1080	1300	1520
	12		129	245	390	550	735	940	1170	1400	1650
	14		138	262	415	590	785	1000	1250	1490	1760
	16		146	278	440	620	830	1065	1320	1580	1870
	18		155	293	463	660	880	1125	1390	1660	1980
	20		162	307	485	690	920	1179	1450	1747	2073
	24		178	338	530	755	1010	1290	1590	1900	2270
	28		195	370	580	825	1100	1400	1720	2070	2460
	32		212	400	630	900	1200	1510	1860	2250	2650
	36		230	432	680	965	1300	1630	2010	2430	2850
	40		248	467	735	1044	1393	1768	2176	2615	3063
24	6		109	205	324	457	610	778	956	1151	1352
	8		122	230	362	510	685	870	1070	1290	1520
	10		132	250	397	560	745	950	1180	1420	1660
	12		142	269	424	603	805	1030	1270	1530	1800
	14		150	285	452	640	860	1100	1350	1630	1930
	16		159	302	480	680	905	1160	1430	1730	2040
	18		168	318	503	715	955	1230	1500	1810	2150
	20		175	332	528	745	1000	1280	1580	1900	2250
	24		191	362	572	817	1089	1391	1716	2060	2447
	28			390	615	880	1175	1500	1850	2230	2650

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

(Continued)

W Feet	*B* Feet	Discharge in c. f. s. Depth of water, (*H*,) in feet 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
24	32			422	665	950	1265	1620	1990	2390	2850
	36			453	715	1020	1355	1730	2130	2560	3040
	40			485	765	1080	1445	1840	2280	2740	3230
	44			520	820	1160	1545	1960	2440	2920	3420
	48			553	876	1233	1640	2080	2600	3100	3620
28	8		133	250	390	560	740	950	1170	1400	1650
	10		144	272	425	610	800	1030	1280	1540	1800
	12		154	292	460	650	865	1110	1380	1650	1950
	14		164	310	487	693	925	1190	1470	1775	2080
	16		173	328	512	730	970	1250	1550	1870	2200
	18		181	343	540	765	1025	1310	1640	1960	2310
	20		190	360	585	800	1070	1370	1700	2050	2420
	24		205	390	610	875	1160	1490	1850	2200	2600
	28		220	419	658	940	1250	1600	1980	2360	2800
	32			450	700	1010	1340	1710	2100	2530	3000
	36			480	750	1070	1430	1820	2250	2700	3180
	40			510	800	1140	1520	1930	2400	2850	3380
	44			540	850	1200	1610	2050	2550	3020	3580
	48			575	900	1280	1700	2170	2700	3200	3760
	52			610	950	1350	1790	2280	2850	3400	3960
	56			643	1002	1427	1891	2400	3000	3580	4170
32	8		131	268	421	598	798	1012	1252	1508	1776
	10		145	292	460	650	870	1110	1360	1650	1940
	12		156	314	492	700	940	1190	1460	1780	2100
	14		168	332	525	745	1000	1270	1550	1900	2230
	16		178	350	552	787	1050	1345	1655	2000	2360
	18		188	370	580	830	1100	1410	1720	2100	2480
	20		200	385	605	860	1150	1475	1800	2200	2600
	24		216	415	655	930	1250	1600	1950	2380	2800
	28		234	445	700	1000	1340	1700	2100	2540	3000
	32		250	473	744	1063	1417	1810	2235	2694	3188
	36				790	1120	1500	1920	2350	2840	3380
	40				840	1180	1580	2030	2500	3000	3550
	44				880	1250	1670	2140	2630	3160	3740
	48				930	1320	1750	2250	2760	3310	3910
	52				980	1380	1850	2360	2900	3500	4100
	56				1025	1460	1950	2480	3060	3660	4300
	60				1075	1530	2050	2600	3200	3840	4500
	64				1136	1613	2153	2724	3380	4030	4700

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

(Continued)

W	B	Discharge in c. f. s.									
		Depth of water, (H,) in feet									
Feet	Feet	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
36	10		165	312	490	700	930	1180	1450	1760	2060
	12		176	335	525	745	990	1270	1560	1890	2220
	14		188	355	555	795	1050	1350	1660	2010	2360
	16		198	374	585	840	1110	1430	1750	2130	2500
	18		208	390	614	874	1165	1500	1850	2220	2610
	20		216	410	640	920	1210	1560	1930	2330	2730
	24		234	440	690	990	1310	1690	2080	2510	2950
	28		250	472	740	1060	1400	1800	2230	2690	3180
	32		265	500	785	1130	1490	1910	2350	2850	3370
	36		279	528	830	1180	1570	2010	2490	3000	3540
	40				880	1250	1660	2120	2600	3180	3750
	44				920	1310	1750	2230	2740	3350	3940
	48				970	1375	1840	2330	2870	3500	4100
	52				1015	1440	1920	2440	3000	3670	4300
	56				1060	1510	2010	2550	3130	3830	4480
	60				1110	1580	2100	2660	3280	4000	4680
	64				1160	1650	2200	2780	3420	4160	4850
	68				1220	1730	2300	2900	3580	4300	5020
	72				1272	1800	2413	3022	3744	4500	5220
40	10		175	331	519	735	982	1249	1536	1844	2187
	12		187	355	560	790	1050	1340	1650	1980	2340
	14		200	378	590	840	1120	1420	1760	2100	2480
	16		210	398	625	880	1180	1500	1860	2220	2620
	18		220	416	655	925	1240	1570	1950	2340	2750
	20		230	435	680	964	1290	1640	2040	2440	2880
	24		248	468	735	1040	1400	1770	2200	2640	3100
	28		265	500	785	1110	1490	1900	2350	2810	3310
	32		280	530	830	1180	1580	2010	2500	2980	3510
	36		295	555	875	1240	1660	2120	2620	3230	3700
	40		309	582	916	1300	1740	2216	2746	3299	3904
	44				960	1360	1830	2330	2880	3450	4100
	48				1000	1425	1900	2430	3000	3600	4250
	52				1050	1480	2000	2550	3150	3750	4350
	56				1100	1550	2080	2650	3280	3900	4620
	60				1140	1620	2150	2750	3410	4080	4800
	64				1190	1680	2250	2870	3560	4230	5000
	68				1240	1750	2350	3000	3700	4400	5150
	72				1290	1820	2430	3100	3850	4600	5350
	76				1350	1900	2530	3230	4000	4750	5550
	80				1403	1984	2640	3379	4160	4964	5769

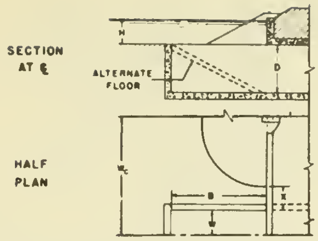
APPENDIX B

RATING TABLES

FOR

RECTANGULAR SPILLWAY

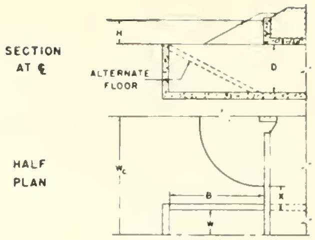
WITH CLOSED-TOP OUTLET



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET
DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE
$W_c = 1.5(W + 2B)$, $X = H$
D = 2 FEET

W Feet	*B* Feet	Discharge in c. f. s. Depth of water, (*H*,) in feet 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
2	1	10.7	13.1									
	2	17.4	20.9									
	3	21.6	25.8									
	4	25.0	29.8	33.4								
4	2	26.8	38.8	45.2	50.6	55.3						
	3	32.5	45.8	53.0	59.0	64.0						
	4	37.1	50.7	57.8	64.0	69.2						
	5	41.5	54.5	61.5	67.5	72.0						
	6	45.5	57.5	64.5								
	7	49.0	59.6	66.0								
	8	52.4	61.7	67.9								
6	3	39.7	66.0	79.0	88.0	96.0						
	4	44.2	73.0	84.0	92.0	101						
	5	49.0	78.0	88.0	96.0	105						
	6	53.6	81.5	91.0	100	108						
	7	57.5	84.5	94.0	103	110						
	8	62.0	87.0	96.5	106	113						
	9	66.0	90.0	99.0								
	10	70.0	92.0	101								
	12	78.0	95.0	104								
8	4	51.6	93.7	112	125	136	145	155				
	5	56.5	100	116	129	140	149					
	6	61.0	105	120	132	142	151					
	7	65.5	109	123	135	145	154					
	8	69.8	112	126	138	147	157					
	9	74.0	115	128								
	10	78.0	118	131								
	12	86.0	122	135								
	14	94.5	127	138								
	16	103	130	141								



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET

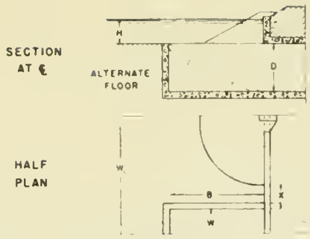
DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$, $X = H$

D = 3 FEET

W	*B*	Discharge in c. f. s.										
		Depth of water, (*H*,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
4	2	27.2	46.0	56.5	62.5							
	4	37.1	66.0	80.0	87.5							
	6	46.0	81.5	95.0	104							
	8	55.2	94.5	106	115	124						
6	3	39.7	74.1	98.4	114	125	134	144	152			
	4	44.8	83.0	112	128	139	149	160	170			
	6	53.6	100	132	147	159	170	180	190			
	8	62.0	115	145	161	172						
	10	71.2	130	155	170	180						
	12	81.0	144	161	176	187						
8	4	51.6	98.5	141	168	184	197	210	222			
	6	61.0	117	165	188	205	220	233	247			
	8	69.8	133	184	204	220	235	250	265			
	10	78.0	148	198	215	230	246	260	277			
	12	87.0	163	210	225	240	255					
	14	96.0	176	215	232	247						
	16	106	190	222	240	255						
10	4	58.0	110	170	210	232	248	265	280			
	6	68.5	132	198	233	255	272	290	305			
	8	77.5	148	220	250	270	288	308	322			
	10	85.5	163	235	262	284	300	320	335			
	12	94.0	179	247	274	294	309	330	342			
	14	103	193	257	283	300	318	337				
	16	111	208	267	290	308						
	18	120	223	275	298	314						
	20	130	237	282	305	320						
12	6	75.0	142	225	281	308	330	351	373	389	409	427
	8	84.5	161	250	295	320	342	365	385	402		
	10	93.0	176	270	310	332	354	378	398	412		
	12	101	192	288	320	345	365	388	405	425		
	14	109	206	302	330	354	375	398	415	432		
	16	118	221	315	340	362	382					
	18	126	236	324	348	370	390					
	20	136	252	333	357	378	398					
	24	155	284	344	370	390	410					



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$; $X = H$

D = 4 FEET

W	*B*	Discharge in c. f. s.										
		Depth of water, *(H,)* in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
4	2	27.2	48.5	60.4	67.7	74						
	4	37.1	70.5	98.4	110	119						
	6	46	87.5	124	137	149						
	8	55.2	104	141	155	168						
6	4	44.8	85	126	154	169						
	6	53.6	102	155	185	204						
	8	62	119	178	209	229						
	10	71.2	135	199	226	245						
	12	81	152	218	240	258						
8	4	51.6	98.5	152	193	220	241	256	270	286	299	313
	6	61	117	183	233	260	280	295	315	330	348	361
	8	69.8	133	210	264	287	308	326	348	362	378	392
	10	78	149	234	287	310	330	347	368			
	12	87	165	255	308	328	346	362				
	14	96	181	276	320	340	358	375				
	16	106	200	296	332	350	367	384				
10	4	58	111	175	225	272	303	322	340	358	376	392
	6	68.5	132	206	275	315	343	365	387	406	424	440
	8	77.5	148	233	310	346	372	396	418	440	458	472
	10	85.5	163	256	338	370	398	420	448	465	480	500
	12	94	179	280	360	390	414	438	465	475	505	
	14	103	195	304	380	408	430	452	482			
	16	111	211	327	397	420	442	468				
	18	120	228	348	408	432	454	478				
	20	130	246	370	420	445	465	490				
12	6	75	142	225	308	370	415	440	465	490	510	530
	8	84.5	160	253	350	410	448	474	500	525	540	560
	10	93	176	280	380	440	470	500	525	550	570	590
	12	101	192	303	408	460	490	520	550	570	590	610
	14	109	208	328	430	478	505	535	565	590	610	
	16	118	223	350	450	492	520	550	580			
	18	126	240	375	468	510	535	560	590			
	20	136	256	400	480	520	545	570				
	24	155	290	445	510	540	565	590				
14	6	81	154	244	345	430	432	515	550	580	605	630
	8	91	173	275	388	468	515	550	585	615	635	665
	10	100	190	300	425	500	540	575	605	635	660	685
	12	108	206	326	455	525	560	595	625	655	680	705
	14	116	221	350	480	545	580	615	640	675	695	720

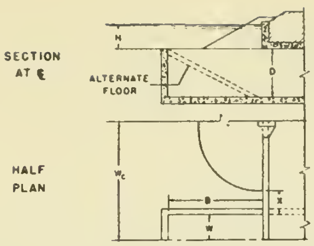
RECTANGULAR SPILLWAY

Discharge Table

D = 4 Feet

(Continued)

W	*B*	Discharge in c. f. s. Depth of water, $(H,)$ in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
14	16	124	235	375	500	560	595	625	655	685	710	
	18	133	252	400	520	580	610	640	670	695	720	
	20	140	267	420	540	590	625	650	680			
	24	158	300	470	570	615	645	670				
	28	177	336	520	600	635	665	690				
16	8	97.5	186	292	417	530	595	630	665	705	735	765
	10	107	204	320	460	560	620	655	690	730	760	790
	12	115	220	348	490	590	635	680	715	745	780	810
	14	124	235	370	520	610	650	700	735	765	800	820
	16	131	250	395	550	630	670	710	750	780	810	835
	18	139	265	420	575	645	685	730	765	795	825	
	20	147	280	440	595	660	700	740	775	810	835	
	24	164	312	490	630	690	725	765	800			
	28	180	345	530	665	710	750	780	810			
	32	200	380	585	695	735	770	800	830			



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$, $X = H$

D = 5 FEET

W	*B*	Discharge in c. f. s.										
		Depth of water, (*H*,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
6	4	44.8	85.0	130	170	191	205	220				
	6	53.6	102	160	212	240	255	274				
	8	62	119	186	248	274	292	313				
	10	71.2	135	212	278	302	322	342				
	12	81.0	152	238	302	323	345	362				
8	4	51.6	98.5	152	210	246	270	290				
	6	61.0	117	182	250	300	328	350				
	8	69.8	133	210	288	344	370	395				
	10	78.0	149	235	320	380	405	430				
	12	87.0	165	260	352	408	430	456				
	14	96.0	181	285	382	428	452	480				
	16	106	200	312	412	448	470	495				
10	4	58	111	175	243	290	330	365	385	410	430	445
	6	68.5	132	206	285	358	400	434	460	482	505	525
	8	77.5	148	233	323	407	445	480	505	530	555	575
	10	85.5	163	256	360	444	485	520	545	570	600	620
	12	94	179	280	395	475	515	545	570	595	630	650
	14	103	195	305	425	505	545	575	600	625	650	
	16	111	211	330	455	530	565	595	620	645		
	18	120	228	358	485	550	580	610	630	660		
	20	130	246	385	520	570	600	625	645	670		
12	6	75	142	225	319	400	465	510	540	575	600	620
	8	84.5	160	253	360	460	520	565	590	625	655	680
	10	93	176	280	398	505	565	605	640	665	695	725
	12	101	192	303	432	545	600	640	670	700	735	765
	14	109	208	328	465	580	625	670	695	720	765	795
	16	118	223	350	500	610	655	695	720	750	785	
	18	126	240	377	530	640	680	715	740	770		
	20	136	256	403	560	660	700	730	760	785		
	24	155	290	458	620	700	730	760	790	815		
14	6	81	154	244	345	435	525	590	635	675	705	735
	8	91	173	275	390	500	595	650	690	730	760	790
	10	100	190	300	425	560	645	700	735	770	805	840
	12	108	206	326	465	600	690	740	770	800	840	875
	14	116	221	350	500	640	720	770	800	830	870	910
	16	124	235	375	535	675	745	795	825	860	895	930
	18	133	252	400	565	705	780	820	845	880	920	
	20	140	267	425	600	740	800	840	870	900	935	
	24	158	300	477	660	780	840	875	900	930		
	28	177	336	530	725	825	860	900	930	960		

RECTANGULAR SPILLWAY

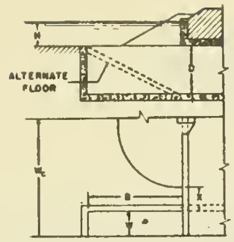
Discharge Table

D = 5 Feet

(Continued)

W	*B*	Discharge in c. f. s.										
		Depth of water, *(H.)* in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
16	8	97.5	186	292	417	540	660	740	790	840	875	900
	10	107	204	320	455	600	720	790	840	880	920	950
	12	115	220	348	495	650	760	830	860	920	955	990
	14	124	235	370	530	695	810	860	910	950	985	1020
	16	131	250	395	565	735	840	890	925	970	1010	1050
	18	139	265	420	600	770	865	920	960	1000	1035	1070
	20	147	280	440	635	800	890	940	980	1015	1050	
	24	164	312	495	700	855	940	980	1010	1050		
	28	180	345	545	760	900	970	1010	1045	1080		
	32	200	380	595	825	950	990	1040	1070	1100		
18	8	104	196	310	440	580	730	830	900	950	1000	1030
	10	114	215	340	485	645	795	880	940	990	1040	1070
	12	123	232	368	525	695	840	920	970	1030	1080	1110
	14	132	250	392	560	745	890	960	1000	1050	1100	1140
	16	140	265	415	595	785	930	990	1030	1080	1130	1170
	18	147	280	440	625	825	960	1015	1050	1100	1150	1190
	20	155	295	463	660	860	980	1040	1075	1120	1170	1210
	24	172	325	510	720	920	1040	1080	1115	1155		
	28	190	358	560	785	980	1075	1110	1150	1190		
	32	207	390	615	860	1030	1100	1145	1185	1220		
	36	225	427	665	925	1070	1130	1180	1210	1250		
20	10	120	228	360	510	680	860	980	1050	1105	1155	1205
	12	129	245	390	545	735	920	1020	1090	1140	1190	1240
	14	138	262	415	585	785	970	1055	1120	1170	1220	1260
	16	146	278	440	620	830	1010	1090	1150	1200	1240	1290
	18	155	293	463	655	880	1045	1110	1175	1225	1265	1310
	20	162	307	485	690	920	1075	1140	1190	1240	1285	1325
	24	178	338	530	755	990	1130	1185	1240	1285	1325	1360
	28	195	370	580	820	1050	1175	1220	1270	1315	1350	1390
	32	212	400	630	885	1100	1205	1255	1300	1350	1385	1420
	36	230	432	680	950	1150	1240	1290	1330	1370	1410	1450
	40	248	467	735	1020	1200	1255	1320	1360	1400	1430	1470

SECTION AT ℄



HALF PLAN

RECTANGULAR SPILLWAY WITH CLOSED-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$; $X = H$

D = 6 FEET

W	*B*	Discharge in c. f. s. Depth of water, *(H,)* in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
6	3	39.7	75.0	115	148	167	179	192	204	217		
	4	44.8	85.0	132	177	206	220	235	250	265		
	6	53.6	102	160	226	271	291	310	327	345		
	8	62.0	119	186	265	320	345	368	388	405		
	10	71.2	135	212	300	360	378	410	430	450		
	12	81.0	152	238	336	390	418	444	464	483	505	520
8	4	51.6	98.5	154	210	263	298	320	340	358		
	6	61.0	117	184	255	325	370	398	418	440		
	8	69.8	133	210	295	380	430	460	480	505		
	10	78.0	149	235	333	425	475	510	530	555		
	12	87.0	165	260	370	465	515	545	570	595		
	14	96.0	181	285	405	500	540	575	605	625		
	16	106	200	312	440	535	565	600	630	650	680	700
10	4	58.0	111	175	244	310	354	395	425	455		
	5	63.6	122	190	268	345	400	440	470	500		
	6	68.5	132	206	290	375	438	430	510	540		
	8	77.5	148	233	330	430	505	545	575	605		
	10	85.5	163	256	366	480	560	600	630	660		
	12	94.0	179	280	400	520	605	640	670	705		
	14	103	195	305	435	565	640	680	710	745		
	16	111	211	330	470	600	670	710	745	780		
	18	120	228	358	505	640	700	740	775	805		
	20	130	246	385	540	680	720	760	800	830	860	880
12	6	75.0	142	225	320	420	500	555	605	645	680	705
	8	84.5	160	253	362	475	570	630	680	720	760	785
	10	93.0	176	280	400	530	630	695	740	780	810	825
	12	101	192	303	433	580	685	750	790	835	875	900
	14	109	208	328	467	625	730	795	830	875	915	940
	16	118	223	350	500	665	770	830	870	910	950	975
	18	126	240	377	535	705	805	860	900	940	975	1000
	20	136	256	403	570	740	840	890	920	960	995	1030
	24	155	290	458	645	815	890	930	960	995	1030	1060
14	6	81.0	154	244	345	460	545	630	695	745	790	825
	7	86.0	164	260	368	490	590	675	740	790	830	875
	8	91.0	173	275	390	520	625	715	780	830	870	910
	10	100	190	300	430	570	700	785	840	890	940	980
	12	108	206	326	465	620	760	845	900	945	990	1030
	14	116	221	350	500	660	810	900	945	990	1040	1080
	16	124	235	375	535	705	860	940	985	1025	1075	1115
	18	133	252	400	570	750	900	980	1025	1060	1110	1150

RECTANGULAR SPILLWAY

Discharge Table

D = 6 Feet

(Continued)

W Feet	*B* Feet	Discharge in c. f. s. Depth of water, (*H*,) in feet 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
14	20	140	267	425	600	790	940	1010	1050	1090	1140	1175
	24	158	300	477	670	870	1000	1060	1100	1140	1185	1220
	28	177	336	530	745	955	1050	1100	1150	1180	1225	1250
16	8	97.5	186	292	417	555	680	790	880	940	990	1040
	10	107	204	320	460	610	750	870	945	1005	1055	1100
	12	115	220	348	495	660	820	940	1000	1060	1110	1160
	14	124	235	370	530	705	880	995	1050	1110	1160	1210
	16	131	250	395	565	750	930	1045	1100	1150	1200	1250
	18	139	265	420	600	795	980	1090	1140	1190	1240	1290
	20	147	280	440	630	835	1020	1125	1170	1220	1270	1310
	24	164	312	495	700	920	1090	1180	1230	1270	1320	1360
	28	180	345	545	770	1000	1150	1220	1265	1315	1360	1405
	32	200	380	595	845	1090	1200	1250	1300	1350	1400	1440
18	8	104	196	310	440	590	730	860	990	1060	1110	1170
	9	109	206	326	464	620	770	900	1020	1090	1150	1210
	10	114	215	340	485	645	810	940	1060	1130	1180	1240
	12	123	232	368	525	695	880	1015	1120	1190	1240	1300
	14	132	250	392	560	745	940	1080	1170	1240	1290	1350
	16	140	265	415	595	790	1000	1140	1215	1280	1330	1390
	18	147	280	440	625	835	1050	1190	1260	1320	1370	1430
	20	155	295	463	660	880	1095	1230	1295	1350	1400	1455
	24	172	325	510	725	960	1180	1300	1350	1410	1460	1510
	28	190	358	560	800	1050	1250	1350	1400	1450	1510	1560
	32	207	390	615	870	1135	1310	1390	1450	1500	1550	1600
	36	225	427	665	945	1230	1370	1425	1490	1530	1600	1630
20	10	120	228	360	510	680	870	1020	1165	1270	1330	1380
	12	129	245	390	550	735	940	1100	1235	1320	1380	1440
	14	138	262	415	590	785	1000	1170	1290	1360	1430	1490
	16	146	278	440	620	830	1060	1240	1340	1400	1460	1530
	18	155	293	463	660	880	1115	1290	1380	1440	1500	1560
	20	162	307	485	690	920	1160	1340	1420	1480	1540	1600
	24	178	338	530	755	1010	1250	1410	1490	1540	1600	1650
	28	195	370	580	825	1090	1330	1480	1550	1590	1640	1690
	32	212	400	630	900	1180	1400	1525	1600	1640	1690	1740
	36	230	432	680	965	1270	1470	1570	1640	1690	1740	1770
	40	248	467	735	1045	1350	1540	1600	1670	1720	1780	1800
24	12	142	270	424	605	800	1030	1265	1460	1595	1670	1740
	14	150	285	452	640	860	1100	1350	1520	1640	1710	1780
	16	159	302	480	680	905	1160	1420	1575	1680	1750	1820
	18	168	318	505	715	955	1230	1480	1620	1720	1790	1850

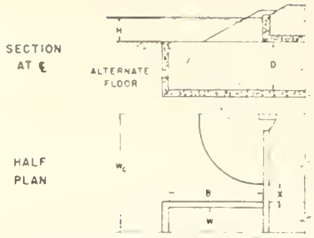
RECTANGULAR SPILLWAY

Discharge Table

D = 6 Feet

(Continued)

W	*B*	Discharge in c. f. s.										
		Depth of water, *(H,)* in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
24	20	175	332	530	745	1000	1280	1535	1660	1750	1830	1890
	24	191	362	570	815	1090	1390	1630	1740	1810	1890	1960
	28		390	615	880	1155	1480	1700	1800	1880	1950	2000
	32		422	665	950	1240	1560	1750	1860	1930	2000	2050
	36		453	715	1020	1330	1650	1810	1910	1980	2050	2100
	40		485	765	1080	1410	1725	1860	1950	2020	2090	2150
	44		520	820	1160	1500	1800	1900	1990	2050	2130	2190
	48		555	875	1235	1610	1870	1950	2030	2095	2170	2220



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE
$W_c = 1.5(W + 2B)$, $X = H$

D = 8 FEET

W	B	Discharge in c. f. s.										
		Depth of water, (H,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
8	4	51.6	98.5	154	215	274	314	342	364	383	400	419
	6	61.0	117	184	260	340	410	460	485	510	535	555
	8	69.8	133	210	300	398	492	555	585	620	650	670
	10	78.0	165	235	339	450	560	635	670	705	735	760
	12	87.0	181	260	375	500	620	700	735	770	805	840
	14	96.0	199	285	410	545	680	755	795	825	865	900
	16	106	200	312	445	590	730	800	840	875	910	955
10	4	58.0	111	175	244	315	370	428	478	510	525	545
	5	63.6	122	190	268	348	420	490	545	580	600	620
	6	68.5	132	206	290	380	465	545	605	640	660	685
	8	77.5	148	233	330	435	545	650	710	750	775	800
	10	85.5	163	256	366	488	615	730	800	840	870	900
	12	94.0	179	280	400	535	680	800	870	910	950	980
	14	103	195	305	435	580	740	870	940	980	1015	1050
	16	111	211	330	470	630	795	925	995	1035	1070	1110
	18	120	228	358	510	675	850	980	1045	1080	1120	1155
	20	130	246	385	545	725	900	1020	1085	1120	1160	1200
12	6	75.0	142	225	320	420	520	620	700	760	795	820
	8	84.5	160	253	362	480	600	720	815	875	915	945
	10	93.0	176	280	400	530	670	810	910	970	1015	1050
	12	101	192	303	433	580	735	890	990	1050	1100	1140
	14	109	208	328	467	625	795	960	1065	1120	1175	1215
	16	118	223	350	505	670	855	1030	1135	1180	1240	1280
	18	126	240	377	540	715	910	1090	1190	1240	1290	1335
	20	136	256	403	570	760	965	1140	1240	1290	1340	1385
	24	155	290	458	645	860	1080	1240	1325	1370	1410	1450
14	6	81.0	154	244	345	460	580	685	790	850	910	950
	7	86.0	164	260	368	490	620	740	850	920	980	1030
	8	91.0	173	275	390	520	655	785	905	980	1040	1090
	10	100	190	300	430	570	725	875	1010	1090	1150	1200
	12	108	206	326	465	620	790	960	1100	1185	1245	1290
	14	116	221	350	500	660	850	1035	1180	1270	1330	1380
	16	124	235	375	535	705	905	1100	1250	1340	1390	1440
	18	133	252	400	570	750	965	1165	1310	1400	1450	1500
	20	140	267	425	600	795	1020	1230	1365	1460	1510	1550
	24	158	300	477	670	890	1140	1340	1470	1550	1600	1640
	28	177	336	530	745	995	1250	1450	1560	1630	1670	1700

RECTANGULAR SPILLWAY

Discharge Table

D = 8 Feet

(Continued)

W	B	Discharge in c. f. s.										
		Depth of water, (*H*,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
16	8	97.5	186	292	417	555	710	860	985	1090	1175	1240
	10	107	204	320	460	610	780	950	1090	1210	1290	1350
	12	115	220	348	495	660	845	1040	1190	1310	1390	1450
	14	124	235	370	530	705	905	1120	1280	1400	1480	1540
	16	131	250	395	565	750	960	1180	1355	1490	1560	1625
	18	139	265	420	600	800	1020	1255	1420	1550	1625	1690
	20	147	280	440	630	840	1080	1330	1490	1620	1690	1750
	24	164	312	495	700	930	1190	1450	1610	1730	1790	1850
	28	180	345	545	770	1030	1310	1570	1710	1810	1860	1910
	32	200	380	595	845	1125	1430	1675	1810	1880	1930	1975
18	8	104	196	310	440	590	750	920	1065	1180	1300	1390
	9	109	206	326	464	620	790	970	1130	1250	1370	1450
	10	114	215	340	485	645	825	1010	1185	1310	1430	1500
	12	123	232	368	525	695	890	1090	1280	1430	1540	1610
	14	132	250	392	560	745	950	1160	1375	1530	1630	1700
	16	140	265	415	595	790	1000	1230	1450	1620	1710	1770
	18	147	280	440	625	835	1065	1305	1540	1700	1790	1850
	20	155	295	463	660	880	1120	1360	1600	1770	1850	1900
	24	172	325	510	725	960	1240	1500	1735	1900	1960	2010
	28	190	358	560	800	1065	1350	1635	1850	2000	2050	2100
	32	207	390	615	870	1160	1470	1760	1950	2080	2130	2170
	36	225	427	665	945	1265	1605	1890	2050	2150	2180	2230
20	10	120	228	360	510	680	870	1070	1250	1410	1560	1670
	12	129	245	390	550	735	940	1150	1360	1530	1680	1790
	14	138	262	415	590	785	1000	1230	1460	1640	1770	1880
	16	146	278	440	620	830	1065	1300	1550	1740	1860	1960
	18	155	293	463	660	880	1125	1370	1640	1830	1940	2040
	20	162	307	485	690	920	1180	1450	1710	1910	2010	2100
	24	178	338	530	755	1010	1290	1580	1850	2050	2140	2220
	28	195	370	580	825	1100	1400	1700	1990	2160	2240	2300
	32	212	400	630	900	1200	1510	1840	2100	2250	2320	2380
	36	230	432	680	965	1300	1630	1960	2200	2330	2400	2450
	40	248	467	735	1045	1395	1770	2100	2300	2400	2450	2500
24	12	142	270	424	605	805	1030	1270	1510	1735	1950	2100
	14	150	285	452	640	860	1100	1350	1610	1850	2050	2200
	16	159	302	480	680	905	1160	1430	1710	1950	2150	2300
	18	168	318	505	715	955	1230	1500	1800	2050	2240	2390
	20	175	332	530	745	1000	1280	1575	1890	2140	2310	2460
	24	191	362	570	815	1090	1390	1715	2050	2300	2450	2600
	28	207	390	615	880	1175	1500	1840	2180	2430	2570	2700
	32	223	422	665	950	1265	1620	1960	2310	2550	2680	2800

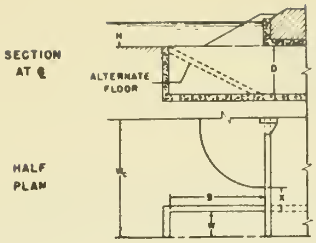
RECTANGULAR SPILLWAY

Discharge Table

D = 8 Feet

(Continued)

W	B	Discharge in c. f. s.										
		Depth of water, *(H,)* in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
24	36		453	715	1020	1355	1730	2080	2450	2650	2760	2870
	40		485	765	1080	1445	1840	2200	2550	2750	2850	2940
	44		520	820	1160	1545	1960	2320	2670	2830	2910	2990
	48		555	875	1235	1640	2080	2450	2780	2900	2960	3020
28	14	164	310	487	695	920	1185	1460	1775	2050	2350	2500
	16	173	328	510	730	970	1250	1540	1870	2160	2450	2600
	18	181	343	540	765	1025	1310	1610	1960	2270	2550	2700
	20	190	360	565	800	1070	1370	1690	2050	2360	2650	2780
	24	205	390	610	875	1160	1490	1840	2210	2550	2810	2940
	28	220	420	660	940	1250	1600	1980	2360	2700	2960	3080
	32		450	700	1000	1340	1710	2120	2510	2830	3080	3180
	36		480	750	1070	1430	1820	2250	2650	2950	3180	3280
	40		510	800	1140	1520	1930	2400	2780	3070	3260	3360
	44		540	850	1200	1610	2050	2540	2900	3150	3330	3420
	48		575	900	1280	1700	2170	2670	3000	3230	3400	3480
	52		610	950	1350	1790	2280	2800	3120	3320	3440	3520
	56		645	1000	1425	1890	2400	2930	3250	3400	3500	3580
32	16	178	350	550	785	1045	1340	1650	2000	2360	2722	3000
	18	188	370	580	830	1100	1410	1730	2100	2490	2830	3090
	20	200	385	605	860	1150	1475	1800	2200	2590	2930	3180
	24	216	415	655	930	1250	1600	1950	2380	2780	3100	3320
	28	234	445	700	1000	1340	1700	2100	2550	2950	3260	3450
	32	250	475	745	1065	1415	1810	2235	2700	3110	3400	3570
	36			790	1120	1500	1920	2360	2850	3240	3500	3660
	40			840	1180	1580	2030	2500	2980	3380	3600	3750
	44			880	1250	1670	2140	2640	3100	3480	3700	3820
	48			930	1320	1750	2250	2760	3230	3580	3780	3900
	52			980	1380	1850	2360	2900	3380	3680	3870	3980
	56			1025	1460	1950	2480	3020	3500	3770	3930	4030
	60			1075	1530	2050	2600	3170	3620	3860	4000	4100
	64			1135	1615	2155	2725	3300	3740	3935	4065	4165



RECTANGULAR SPILLWAY
WITH
CLOSED-TOP OUTLET

DISCHARGE TABLE

MINIMUM DIMENSIONS FOR USING TABLE

$W_c = 1.5(W + 2B)$, $X = H$

D = 10 FEET

W	B	Discharge in c. f. s.										
		Depth of water, (H,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
10	4	58.0	111	175	244	320	400	450	482	505	530	550
	5	63.6	122	190	268	353	445	510	565	595	625	655
	6	68.5	132	206	291	385	488	570	640	680	715	750
	8	77.5	148	233	330	440	560	670	775	840	880	920
	10	85.5	163	256	366	488	625	765	890	975	1015	1060
	12	94.0	179	280	400	535	690	845	990	1085	1140	1185
	14	103	195	305	435	585	750	920	1085	1190	1240	1290
	16	111	211	330	470	630	810	1000	1170	1270	1320	1370
	18	120	228	358	510	682	870	1070	1240	1340	1390	1440
	20	130	246	385	545	725	925	1145	1300	1400	1450	1500
12	6	75.0	142	225	320	424	535	630	735	810	880	920
	8	84.5	160	253	362	480	610	730	860	960	1040	1090
	10	93.0	176	280	400	530	675	820	970	1100	1180	1240
	12	101	192	303	433	580	735	905	1070	1210	1300	1360
	14	109	208	328	467	625	800	980	1165	1315	1400	1470
	16	118	223	350	505	670	855	1060	1250	1410	1500	1560
	18	126	240	377	540	715	915	1130	1340	1500	1580	1650
	20	136	256	403	570	760	970	1200	1410	1560	1640	1720
	24	155	290	458	645	860	1090	1360	1560	1700	1760	1840
14	6	81.0	154	244	345	460	580	700	820	920	1010	1080
	7	86.0	164	260	368	490	620	750	890	1000	1100	1170
	8	91.0	173	275	390	520	655	795	950	1070	1180	1260
	10	100	190	300	430	570	725	880	1050	1205	1320	1410
	12	108	206	326	465	620	790	960	1150	1330	1450	1550
	14	116	221	350	500	660	850	1045	1245	1440	1560	1660
	16	124	235	375	535	705	905	1110	1340	1540	1660	1770
	18	133	252	400	570	750	965	1180	1420	1640	1750	1860
	20	140	267	425	600	795	1025	1250	1510	1720	1830	1940
	24	158	300	477	670	890	1140	1400	1680	1870	1980	2070
	28	177	336	530	745	995	1270	1570	1840	2010	2100	2170
16	8	97.5	186	292	417	555	710	860	1030	1180	1300	1400
	10	107	204	320	460	610	780	950	1130	1310	1450	1560
	12	115	220	348	495	660	845	1035	1230	1435	1585	1700
	14	124	235	370	530	705	905	1105	1320	1545	1700	1830
	16	131	250	395	565	750	960	1185	1410	1650	1810	1950
	18	139	265	420	600	800	1020	1250	1490	1750	1900	2050
	20	147	280	440	630	840	1080	1330	1570	1840	2000	2130
	24	164	312	495	700	930	1190	1480	1750	2000	2150	2280
	28	180	345	545	770	1030	1310	1630	1920	2150	2300	2400
	32	200	380	595	845	1125	1430	1775	2100	2310	2430	2500

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

W	*B*	Discharge in c. f. s.										
		Depth of water, (H_e) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
18	8	104	196	310	440	590	750	930	1100	1280	1420	1510
	9	109	206	326	464	620	790	975	1160	1350	1500	1610
	10	114	215	340	485	645	825	1015	1210	1410	1570	1700
	12	123	232	368	525	695	890	1090	1310	1540	1710	1850
	14	132	250	392	560	745	950	1165	1400	1650	1840	2000
	16	140	265	415	595	790	1000	1230	1490	1750	1950	2120
	18	147	280	440	625	835	1065	1305	1575	1860	2060	2240
	20	155	295	463	660	880	1120	1360	1650	1950	2150	2340
	24	172	325	510	725	960	1240	1500	1830	2120	2330	2510
	28	190	358	560	800	1065	1350	1650	2000	2300	2490	2650
	32	207	390	615	870	1160	1470	1800	2170	2450	2630	2750
	36	225	427	665	945	1265	1605	1975	2350	2610	2760	2850
20	10	120	228	360	510	680	870	1080	1300	1500	1685	1835
	12	129	245	390	550	735	940	1170	1400	1630	1840	2000
	14	138	262	415	590	785	1000	1250	1490	1750	1980	2150
	16	146	278	440	620	830	1065	1320	1580	1860	2100	2280
	18	155	293	463	660	880	1125	1390	1660	1970	2210	2400
	20	162	307	485	690	920	1180	1450	1750	2075	2320	2515
	24	178	338	530	755	1010	1290	1590	1900	2270	2510	2710
	28	195	370	580	825	1100	1400	1720	2070	2450	2690	2880
	32	212	400	630	900	1200	1510	1860	2250	2610	2850	3010
	36	230	432	680	965	1300	1630	2010	2430	2760	2980	3130
	40	248	467	735	1045	1395	1770	2175	2615	2930	3120	3230
24	12	142	270	424	605	805	1030	1270	1530	1790	2050	2250
	14	150	285	452	640	860	1100	1350	1630	1900	2170	2410
	16	159	302	480	680	905	1160	1430	1730	2020	2290	2560
	18	168	318	505	715	955	1230	1500	1810	2140	2400	2700
	20	175	332	530	745	1000	1280	1580	1900	2240	2500	2840
	24	191	362	570	815	1090	1390	1715	2060	2450	2720	3080
	28		390	615	880	1175	1500	1850	2230	2630	2900	3280
	32		422	665	950	1265	1620	1990	2390	2810	3100	3430
	36		453	715	1020	1355	1730	2130	2560	3000	3270	3590
	40		485	765	1080	1445	1840	2280	2740	3170	3420	3700
	44		520	820	1160	1545	1960	2440	2920	3320	3600	3800
	48		555	875	1235	1640	2080	2600	3100	3500	3780	3900
28	14	164	310	487	695	925	1190	1470	1775	2075	2380	2650
	16	173	328	512	730	970	1250	1550	1870	2190	2520	2800
	18	181	343	540	765	1025	1310	1640	1960	2300	2650	2960
	20	190	360	585	800	1070	1370	1700	2050	2400	2780	3100
	24	205	390	610	875	1160	1490	1850	2200	2600	3010	3380

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

(Continued)

W	*B*	Discharge in c. f. s.										
		Depth of water, $(H.)$ in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
28	28	220	420	660	940	1250	1600	1980	2360	2800	3240	3600
	32		450	700	1010	1340	1710	2100	2530	2980	3440	3790
	36		480	750	1070	1430	1820	2250	2700	3170	3620	3980
	40		510	800	1140	1520	1930	2400	2850	3360	3800	4120
	44		540	850	1200	1610	2050	2550	3020	3540	3980	4280
	48		575	900	1280	1700	2170	2700	3200	3720	4120	4400
	52		610	950	1350	1790	2280	2850	3400	3900	4280	4520
	56		645	1000	1425	1890	2400	3000	3580	4100	4450	4650
32	16	178	350	550	785	1050	1345	1655	2000	2360	2730	3050
	18	188	370	580	830	1100	1410	1720	2100	2480	2860	3210
	20	200	385	605	860	1150	1475	1800	2200	2600	3000	3380
	24	216	415	655	930	1250	1600	1950	2380	2800	3240	3680
	28	234	445	700	1000	1340	1700	2100	2540	3000	3480	3920
	32	250	475	745	1065	1415	1810	2235	2695	3190	3700	4150
	36			790	1120	1500	1920	2350	2840	3380	3900	4350
	40			840	1180	1580	2030	2500	3000	3550	4100	4520
	44			880	1250	1670	2140	2630	3160	3740	4280	4700
	48			930	1320	1750	2250	2760	3310	3910	4450	4850
	52			980	1380	1850	2360	2900	3500	4100	4620	5000
	56			1025	1460	1950	2480	3060	3660	4300	4800	5120
	60			1075	1530	2050	2600	3200	3840	4500	4950	5250
	64			1135	1615	2155	2725	3380	4030	4650	5100	5350
36	18	208	390	615	875	1165	1500	1850	2220	2610	3050	3490
	20	216	410	640	920	1210	1560	1930	2330	2730	3180	3640
	24	234	440	690	990	1310	1690	2080	2510	2950	3420	3930
	28	250	472	740	1060	1400	1800	2230	2690	3180	3670	4200
	32	265	500	785	1130	1490	1910	2350	2850	3370	3880	4420
	36	280	530	830	1180	1570	2010	2490	3000	3540	4100	4650
	40			880	1250	1660	2120	2600	3180	3750	4300	4830
	44			920	1310	1750	2230	2740	3350	3940	4500	5020
	48			970	1375	1840	2330	2870	3500	4100	4680	5200
	52			1015	1440	1920	2440	3000	3670	4300	4850	5350
	56			1060	1510	2010	2550	3130	3830	4480	5050	5520
	60			1110	1580	2100	2660	3280	4000	4680	5200	5680
	64			1160	1650	2200	2780	3420	4160	4850	5400	5820
	68			1220	1730	2300	2900	3580	4300	5020	5600	5950
	72			1270	1800	2415	3020	3745	4500	5220	5800	6100

RECTANGULAR SPILLWAY

Discharge Table

D = 10 Feet

(Continued)

W	*B*	Discharge in c. f. s.										
		Depth of water, (*H*,) in feet										
Feet	Feet	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
40	20	230	435	680	965	1290	1640	2040	2440	2880	3370	3860
	24	248	468	735	1040	1400	1770	2200	2640	3100	3600	4170
	28	265	500	785	1110	1490	1900	2350	2810	3310	3860	4450
	32	280	530	830	1180	1580	2010	2500	2980	3510	4100	4700
	36	295	555	875	1240	1660	2120	2620	3230	3700	4300	4950
	40	309	580	915	1300	1740	2215	2745	3300	3900	4530	5200
	44			960	1360	1830	2330	2880	3450	4100	4750	5400
	48			1000	1425	1900	2430	3000	3600	4250	4950	5600
	52			1050	1480	2000	2550	3150	3750	4350	5150	5800
	56			1100	1550	2080	2650	3280	3900	4620	5330	5950
	60			1140	1620	2150	2750	3410	4080	4800	5500	6100
	64			1190	1680	2250	2870	3560	4230	5000	5700	6250
	68			1240	1750	2350	3000	3700	4400	5150	5900	6400
	72			1290	1820	2430	3100	3850	4600	5350	6050	6550
	76			1350	1900	2530	3230	4000	4750	5550	6250	6700
	80			1405	1985	2640	3380	4160	4960	5770	6450	6850

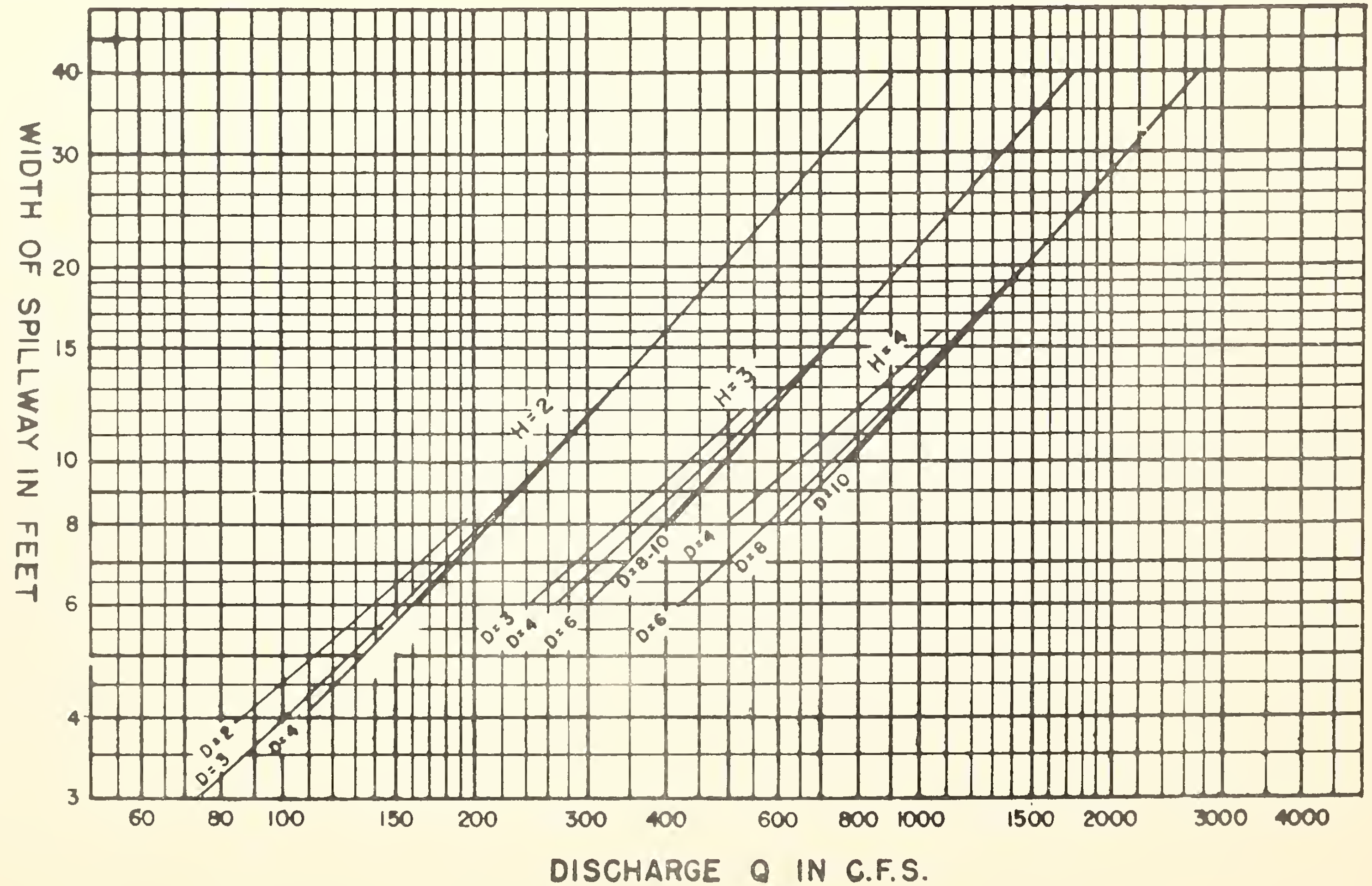
APPENDIX C

PREPARATION OF RATING TABLES

The procedure used for preparing tables for the open-top spillway will be described, the same procedure being applicable to the closed-top spillway. The first step is to tabulate for each value of D the corresponding values of W and B for each group of coefficient curves. Table 2, page 64, illustrates the tabulations and computations for a square-shaped spillway where B = W for one value of D. Similar tables were prepared for other values of D and for spillway lengths B = 0.25W, B = 0.5W, and B = 2W. The total length of the spillway crest (L) was determined and values of H/L were computed for each 0.5 foot of head up to 5.0 feet or the maximum range calibrated in the laboratory. For each value of H/L the coefficient was taken from the coefficient curve representing the particular ratio of W to D. The discharge was then computed for each head for the various spillways and plotted so as to give intermediate values of the width (W) and corresponding length (B) for each depth and head. The curves in figure 16, page 65, illustrate the method and general characteristics of the curves for square spillways (B = W). Similar curves were plotted for other values of H for this spillway. Using these curves it was possible to tabulate, for each value of D, discharge values for any value of W as long as B was equal to W. Table 3, page 66, was prepared to illustrate some of the values which are obtained from these curves.

TABLE 2.--*Computation of prototype discharges using coefficient curves, B = W*

D (ft.)	W (ft.)	B (ft.)	L (ft.)	H (ft.)	H/L	C	$H^{1.5}$	$CLH^{1.5}$ (cfs)
				$W = D$				
2	2	2	6	0.5	0.0833	3.09	0.3536	6.55
				1.0	.167	3.17	1.000	19.0
				$W = 2D$				
	4	4	12	.5	.0416	2.91	.3536	12.3
				1.0	.0833	3.09	1.000	37.1
				1.5	.125	2.90	1.837	63.9
				2.0	.167	2.54	2.828	86.2
				2.5	.208	2.28	3.953	108
				$W = 4D$				
	8	8	24	.5	.0208	2.74	.3536	23.2
				1.0	.0416	2.91	1.000	69.8
				1.5	.0625	3.01	1.837	133
				2.0	.0833	2.80	2.828	190
				2.5	.104	2.50	3.953	237
				3.0	.125	2.28	5.196	284
				3.5	.146	2.11	6.548	332
				4.0	.167	1.97	8.000	378
				4.5	.187	1.86	9.546	426
				5.0	.208	1.76	11.18	472



RECTANGULAR SPILLWAY
DISCHARGE CURVES
B = W

S.C.S. PROJECT MN-R-3 SEPT. 1943

FIGURE 16

TABLE 3.--*Discharge of rectangular spillway, D = 4 feet, B = W, discharge in c. f. s.*

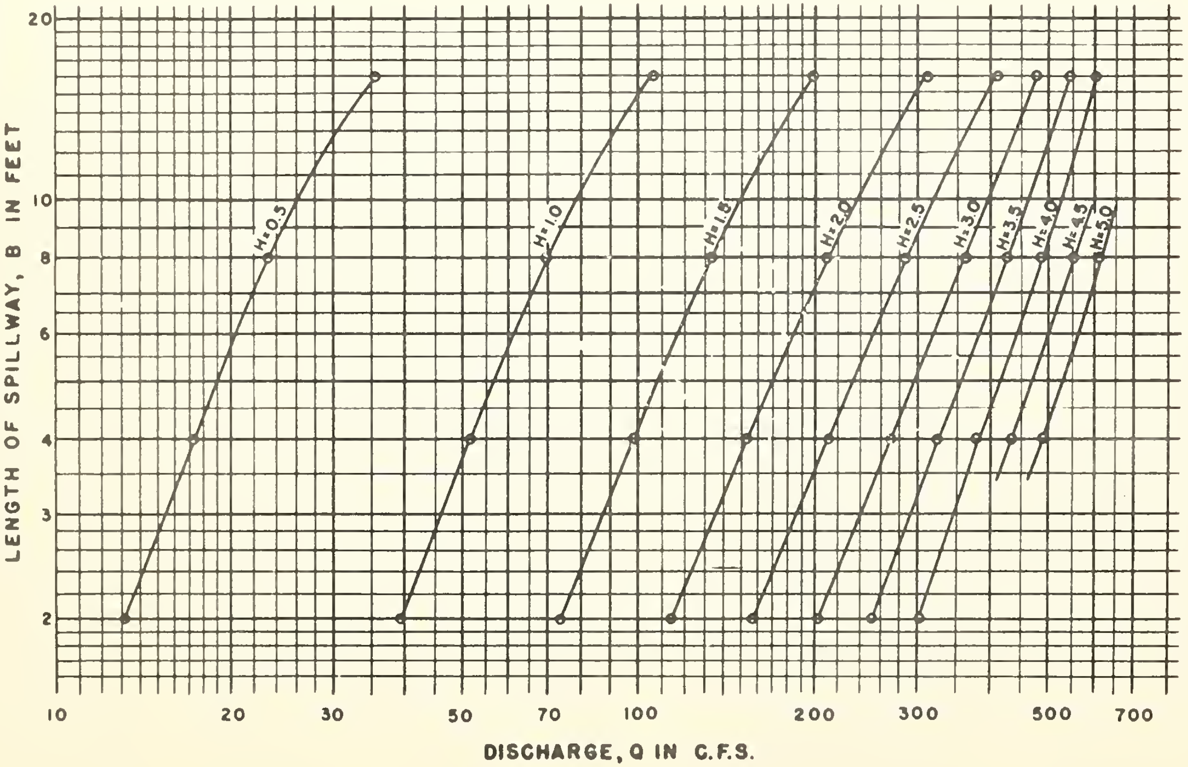
		Depth of water (*H*) in feet		
W ft.	*B* ft.	2.0	3.0	4.0
4	4	107		
6	6	158	262	
8	8	210	362	488
10	10	256	462	630
12	12	303	557	780
14	14	350	655	920
16	16	395	751	1075

It is apparent that many different sizes of spillways (all having the same value of *D*) could be selected from this table to carry the same discharge, but all of the spillways would be square in shape. By plotting curves for the other series of tests, it was possible to prepare similar tables with values for B of 0.25*W*, 0.5*W*, and 2*W*. Having these tables prepared, their range of usefulness is limited because it is necessary to select one of the length-to-width ratios which was tested. Therefore, discharge curves were plotted as shown in *figure* 17, *page 67*, using the data shown in *table 4* which was taken from the group of curves used in determining intermediate ratios of width to depth.

TABLE 4.--*Discharge of rectangular spillway for D = 4 feet*

		Depth of water (*H*) in feet									
W	*B*	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
8	2	13.1	39.1	73.8	114	157	203	251	302		
	4	17.2	51.6	98.5	154	212	270	324	379	434	492
	8	23.2	69.8	133	210	286	362	427	488	552	612
	16	35.5	106	199	310	411	478	545	602		

From these curves the discharge for intermediate lengths of spillway having the same width and depth can be determined. Similar groups of curves for each value of *W* and for each value of *D* were plotted for use in preparing the final rating tables.



RECTANGULAR SPILLWAY

DISCHARGE CURVES

DEPTH, D = 4 FEET

WIDTH, W = 8 FEET

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FIGURE 17